

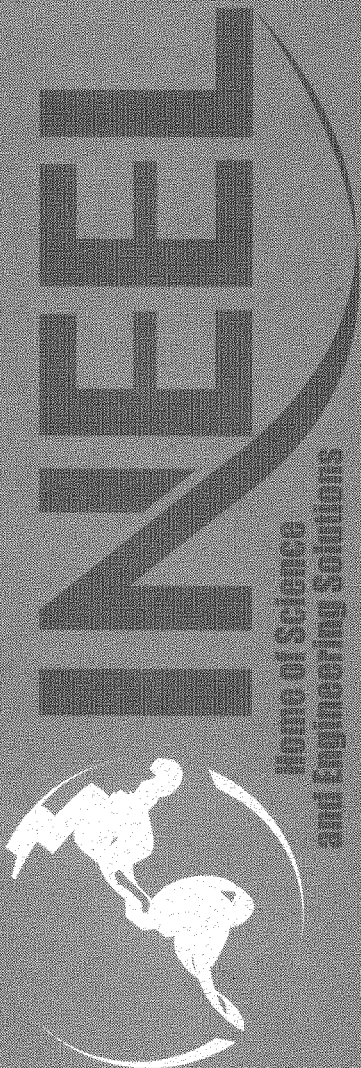
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September 2002

Science Action Team 2002 Report for Waste Area Group 4

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**Idaho National Engineering and Environmental Laboratory
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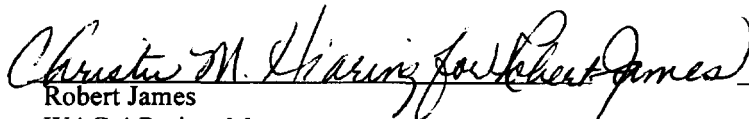
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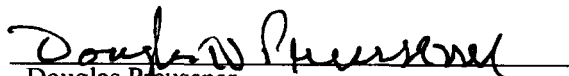
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ABSTRACT

The Environmental Restoration Department at the Idaho National Engineering and Environmental Laboratory, sponsored a Science Action Team (SAT) to study and survey vegetation, small mammals, rooting depths, and small mammal burrows at Waste Area Group (WAG) 4. The SAT conducted these studies at the Central Facilities Area Landfills I, II, and III, and at a control area east of Landfill III. Deep rooting plant species and small mammal burrows may impact the performance of the compacted soil barriers placed on the CFA landfills in the long term. These biological processes may influence water infiltration through the barriers into the buried waste and migration of contamination down through the soil column into the Snake River Plain Aquifer.

The impact on the landfills from biological processes is a long-term issue that will require continued monitoring until further analysis can be completed. A more detailed analysis of the issues presented in this report will be discussed further in EDF-2482, "Analysis of the Natural Physical and Biological Processes Potentially Affecting the Long-Term Performance of the Compacted Soil Barriers on the CFA Landfills."

CONTENTS

ABSTRACT	iii
ACRONYMS	ix
1. INTRODUCTION	1-1
2. LOCATION AND BACKGROUND	2-1
2.1 Central Facilities Area	2-1
2.2 Central Facilities Area Landfills.....	2-1
2.2.1 Physical Characteristics of the Central Facilities Area Landfills I, II, and III.....	2-1
2.2.2 Landfill I.....	2-5
2.2.3 Landfill II.....	2-5
2.2.4 Landfill III	2-5
3. REMEDIAL ACTION AT THE CENTRAL FACILITIES AREA LANDFILLS I, II, AND III.....	3-1
3.1 Remedy Implementation.....	3-1
3.1.1 Plants Used to Revegetate the CFA Landfills	3-1
4. JUSTIFICATION.....	4-1
5. OBJECTIVES	5-1
6. METHODS	6-1
6.1 Trapping Small Mammals	6-1
6.1.1 Methods for Determining Small Mammal Populations.....	6-4
6.2 Vegetation Density and Cover Analysis.....	6-5
6.2.1 Line Intercept Method	6-5
6.2.2 Daubenmire Method	6-5
7. RESULTS	7-1
7.1 Small Mammals Captured on the CFA Landfills and the Control Area.....	7-1
7.1.1 Analysis of Small Mammals Captured on CFA Landfill I, II, III, and the Control Area	7-2
7.2 Small Mammal Populations.....	7-4
7.2.1 CFA Landfill I Small Mammal Populations.....	7-4

7.2.2	CFA Landfill II Small Mammal Populations	7-4
7.2.3	CFA Landfill III Small Mammal Populations	7-5
7.2.4	Control Area Small Mammal Populations.....	7-5
7.3	Small Mammal Burrowing Depths.....	7-6
7.4	Vegetation Surveys.....	7-9
7.4.1	Results of the Vegetation Surveys on CFA Landfill I.....	7-12
7.4.2	Results of the Vegetation Surveys on CFA Landfill II.....	7-13
7.4.3	Results of the Vegetation Surveys on CFA Landfill III	7-13
7.4.4	Results of the Vegetation Surveys on the Control Area.....	7-17
7.5	The Percent Cover for the CFA Landfill I, II, III and the Control Area using Vegetation Groups	7-17
7.6	Changes in Plant Species Since the Revegetation Efforts	7-21
7.6.1	Plants Used to Revegetate the CFA Landfills	7-21
7.6.2	Plant Species Currently Growing on the CFA Landfills	7-21
7.6.3	Plant Species Observed in the Control Area.....	7-23
7.7	Rooting Depths of Common Plant Species Identified on the CFA Landfills.....	7-24
8.	RESULTS SUMMARY AND CONCLUSIONS	8-1
8.1	Summary of Small Mammal Densities and Burrowing Depth Results	8-1
8.2	Summary of the Vegetation Density and Cover Analysis and Rooting Depth Results	8-2
8.3	Current Successional Changes of Plant Species on CFA Landfills I, II, and III	8-4
9.	SUMMARY	9-1
10.	REFERESUNCES	10-1
Appendix A—Science Action Team Photographs		
Appendix B—Small Mammal Species Captured on CFA Landfills I, II, and III		
Appendix C—Plant Species Observed on CFA Landfills I, II, and III		
Appendix D—Inventory of Small Mammals Captured on the CFA Landfills and Control Area		

FIGURES

2-1.	Location of the Central Facilities Area (WAG 4).....	2-2
2-2.	Location of the CFA landfills	2-3
2-3.	Landfills and control area in relation to the roads.....	2-4

6-1.	The layout of the transect lines on CFA Landfill I	6-1
6-2.	The layout of the transect lines on CFA Landfill II	6-2
6-3.	The layout of the transect lines on CFA Landfill III	6-3
6-4.	The layout of the transect lines on the control area	6-4
7-1.	The percentage of each small mammal captured on CFA Landfill I	7-2
7-2.	The percentage of each small mammal captured on CFA Landfill II	7-2
7-3.	The percentage of each small mammal captured on CFA Landfill III	7-3
7-4.	The percentage of each small mammal captured on the control area	7-3
7-5.	Percent cover of all plant species surveyed on CFA Landfill I using the Daubenmire method.....	7-12
7-6.	Percent cover of all plant species surveyed on Landfill I using the line-intercept method.....	7-12
7-7.	Percent frequency of all plant species surveyed in CFA Landfill I using the Daubenmire method.....	7-13
7-8.	Percent cover of all plant species surveyed in CFA Landfill II using the Daubenmire method.....	7-14
7-9.	Percent cover of all plant species surveyed in Landfill II using the line-intercept method	7-14
7-10.	Percent frequency of all plant species surveyed in CFA Landfill II using the Daubenmire method.....	7-15
7-11.	Percent cover of all plant species surveyed in CFA Landfill III using the Daubenmire method.....	7-16
7-12.	Percent cover of all species surveyed in CFA Landfill III using the line-intercept method	7-16
7-13.	Percent frequency of all plant species surveyed on CFA Landfill III using the Daubenmire method.....	7-17
7-14.	Percent cover of all plant species surveyed in the control area using the Daubenmire method.....	7-18
7-15.	Percent cover of all plant species surveyed in the control area using the line-intercept method.....	7-18
7-16.	Percent frequency of all plant species surveyed in the control area using the Daubenmire method.....	7-19
7-17.	The percent cover according to the assigned plant groups at CFA Landfill I.....	7-19
7-18.	The percent cover according to the assigned plant groups at CFA Landfill II	7-20
7-19.	The percent cover according to the assigned plant groups at CFA Landfill III	7-20

7-20. The percent cover according to the assigned plant groups in the control area east of CFA Landfill III.....	7-21
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TABLES

6-1. Vegetation cover classes for the Daubenmire method	6-6
7-1. Total small mammal species captured on each of the trapping locations	7-1
7-2. The population size of small mammals captured at all trapping locations on CFA Landfill I.....	7-4
7-3. The population size of small mammals captured at all trapping locations on CFA Landfill II	7-5
7-4. The population size of small mammals captured at all trapping locations on CFA Landfill III.....	7-5
7-5. The population size of small mammals captured at all trapping locations on the control area.....	7-6
7-6. Maximum and average burrowing depths of the most common small mammals captured on the CFA landfills and the control area	7-6
7-7. Number of small mammal burrows observed on CFA Landfills I, II, and III	7-7
7-8. The average and range of burrow diameters of small mammal species identified on the CFA Landfills	7-8
7-9. The percent frequency of plant species observed in the control area using the Daubenmire method and the line-intercept method.....	7-23
7-10. The maximum rooting depths of common plant species found in the CFA landfills and the control area.....	7-24
8-1. Summary of populations and burrowing depths of common small mammals captured on CFA Landfills I, II, II, and the control area	8-2
8-2. Summary of percent cover, percent frequency, and rooting depths of the most common plant species identified on CFA Landfills I, II, III, and the control area	8-3

ACRONYMS

ARAR	applicable or relevant and appropriate requirements
CFA	Central Facilities Area
DOE-ID	U.S. Department of Energy Idaho Operations Office
EDF	engineering design file
ESRP	Eastern Snake River Plain
INEEL	Idaho National Engineering and Environmental Laboratory
ROD	record of decision
SAT	Science Action Team
WAG	waste area group

Science Action Team 2002 Report for Waste Area Group 4

1. INTRODUCTION

The Idaho National Engineering and Environmental Laboratory (INEEL) has a number of buried waste sites that have been remediated with various natural biobarriers to prevent release and possible exposure from buried hazardous contaminants. The INEEL has planted grass seed mixes on these biobarriers to prevent erosion and water infiltration and to preserve their integrity. Biological processes may compromise the long-term performance of native soil barriers, such as the compacted soil barrier at the Central Facilities Area (CFA). The Environmental Restoration project manager for Waste Area Group (WAG) sponsored a Science Action Team (SAT) to study and survey vegetation, small mammals, and their burrows at the CFA Landfills I, II, and III, and at a control area east of Landfill III. WAG 4 organized this study because of a concern that deep rooting plants and small burrowing mammals could create pathways for water to leach through the compacted soil barriers and into the buried waste at the landfills. This could then result in contamination migration down through the soil column and into the Snake River Plain Aquifer. This study will also address potential effects from successional activities of vegetation growing in areas adjacent to the CFA landfills.

The results from these studies were used to identify data gaps related to long-term effects of biological processes at the landfills. The results of the data gap analysis will be presented in EDF-2482, "Analysis of the Natural Physical and Biological Processes Potentially Affecting the Long-Term Performance of the Compacted Soil Barriers on the CFA Landfills." The following sections provide a history of the CFA and its associated landfills; an overview of the remedial action conducted at the CFA Landfills I, II, and III; justification and objectives for the SAT methods used in the study; and finally the results of the study.

2. LOCATION AND BACKGROUND

2.1 Central Facilities Area

The WAG 4 comprises the CFA, which is located in the south-central portion of the INEEL (see Figure 2-1). Built in the 1940s and 1950s, the original buildings at the CFA, housed Navy gunnery-range personnel and included administration, shop, and warehouse space. The facilities have been modified throughout the years to fit changing needs and now provide four major types of functional space: (1) craft, (2) office, (3) service, and (4) laboratory.

Since 1949, the CFA has been used to house many support services for all of the operations at the INEEL. These support services include laboratories, security, fire protection, medical, communication systems, warehouses, a cafeteria, vehicle and equipment pools, bus system, and laundry facilities. Approximately 1,028 people work at the CFA.

2.2 Central Facilities Area Landfills

The actual amount of hazardous waste disposed of in the CFA landfills is unknown because the waste-disposal inventory records are incomplete. Existing records show that the major types of waste accepted at the landfills included trash sweepings, cafeteria garbage, wood and scrap lumber, masonry concrete, scrap metal, weeds, grass, dirt, gravel, asphalt, and asbestos. To a lesser extent, Landfill III also accepted waste oil, solvents, chemicals, and paint. The following subsections discuss the landfills in more detail.

2.2.1 Physical Characteristics of the Central Facilities Area Landfills I, II, and III

The CFA landfills are located on the Eastern Snake River Plain (ESRP) in Big Lost River alluvial deposits overlying basalt bedrock. Figure 2-2 shows the location of the landfills and Figure 2-3 shows the landfills and the control area in relation to the roads. The sediments composing these deposits are primarily sands and gravels that contain very few fine-grained materials. In some places, however, a clay-rich layer (0 to 2.7 m [0 to 9 ft]) thick exists above the bedrock. Depth to basalt at these landfills ranges from 3.0 to 11.2 m (10 to 37 ft). The vadose zone, that portion of the earth that extends from the land surface down to the water table, is approximately 146 m (480 ft) thick at the CFA landfills. It is composed of a relatively thin layer of surface sediments, in which the wastes are located, and thick sequences of basalt flows containing interbedded sediments. Because of the relatively low annual precipitation, high potential evapotranspiration, and deep water table, vadose zone soils at the landfills tend to be relatively dry during most of the year. The spring snowmelt event provides the greatest source of water available for infiltration into the landfills. The Snake River Plain Aquifer, one of the largest and most productive groundwater resources in the United States, underlies the CFA landfills.

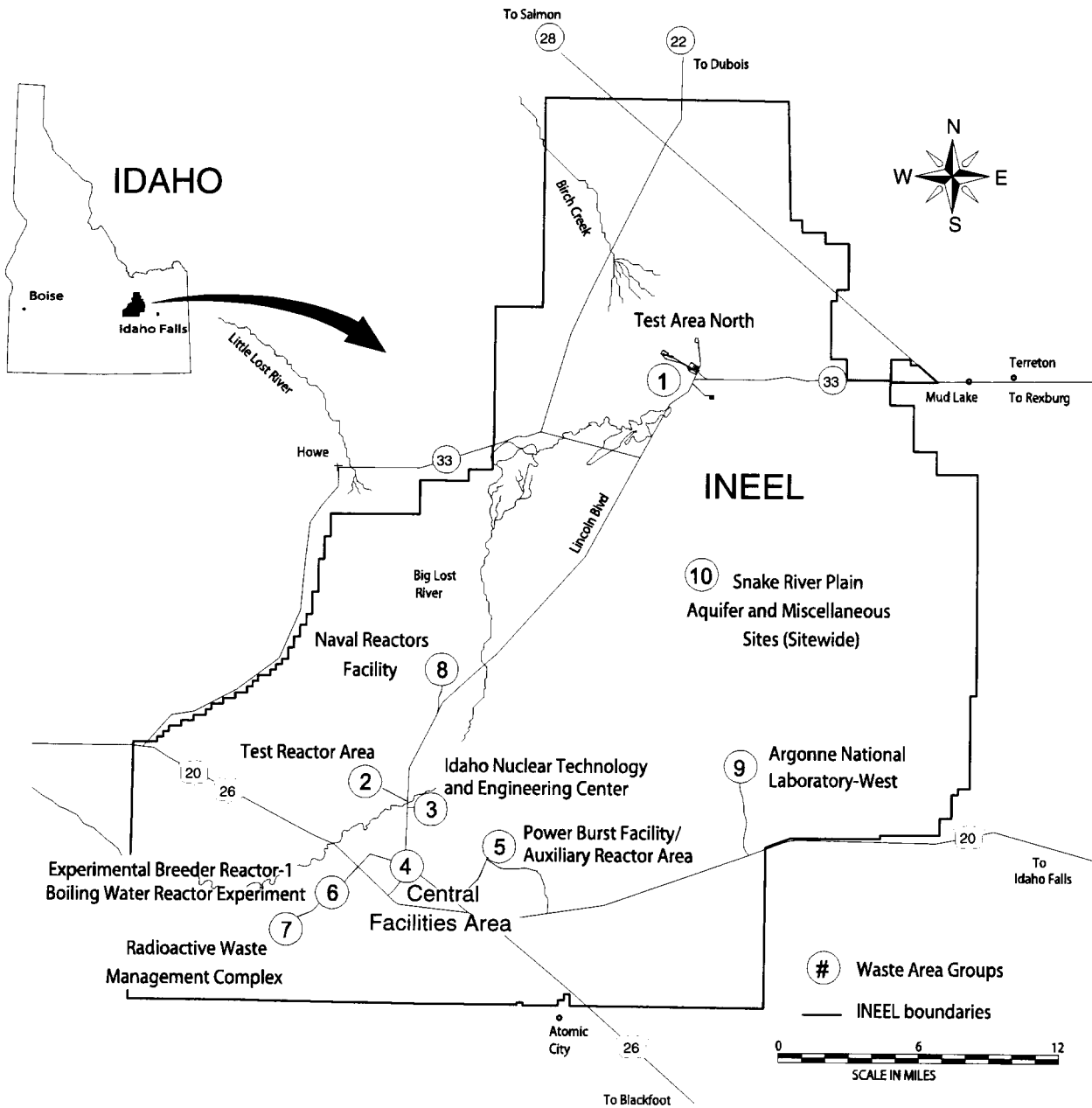


Figure 2-1. Location of the Central Facilities Area (WAG 4).

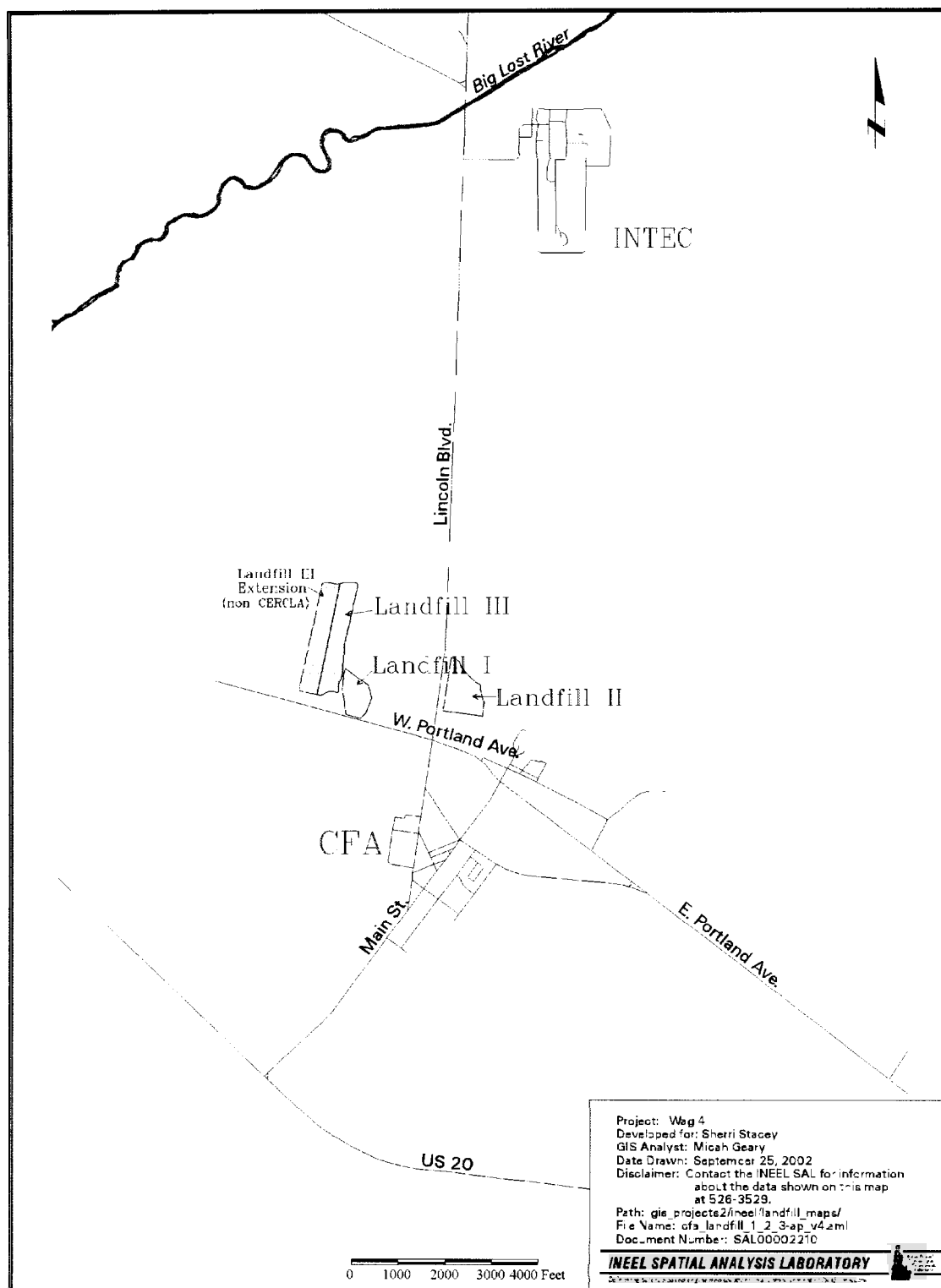


Figure 2-2. Location of the CFA landfills.

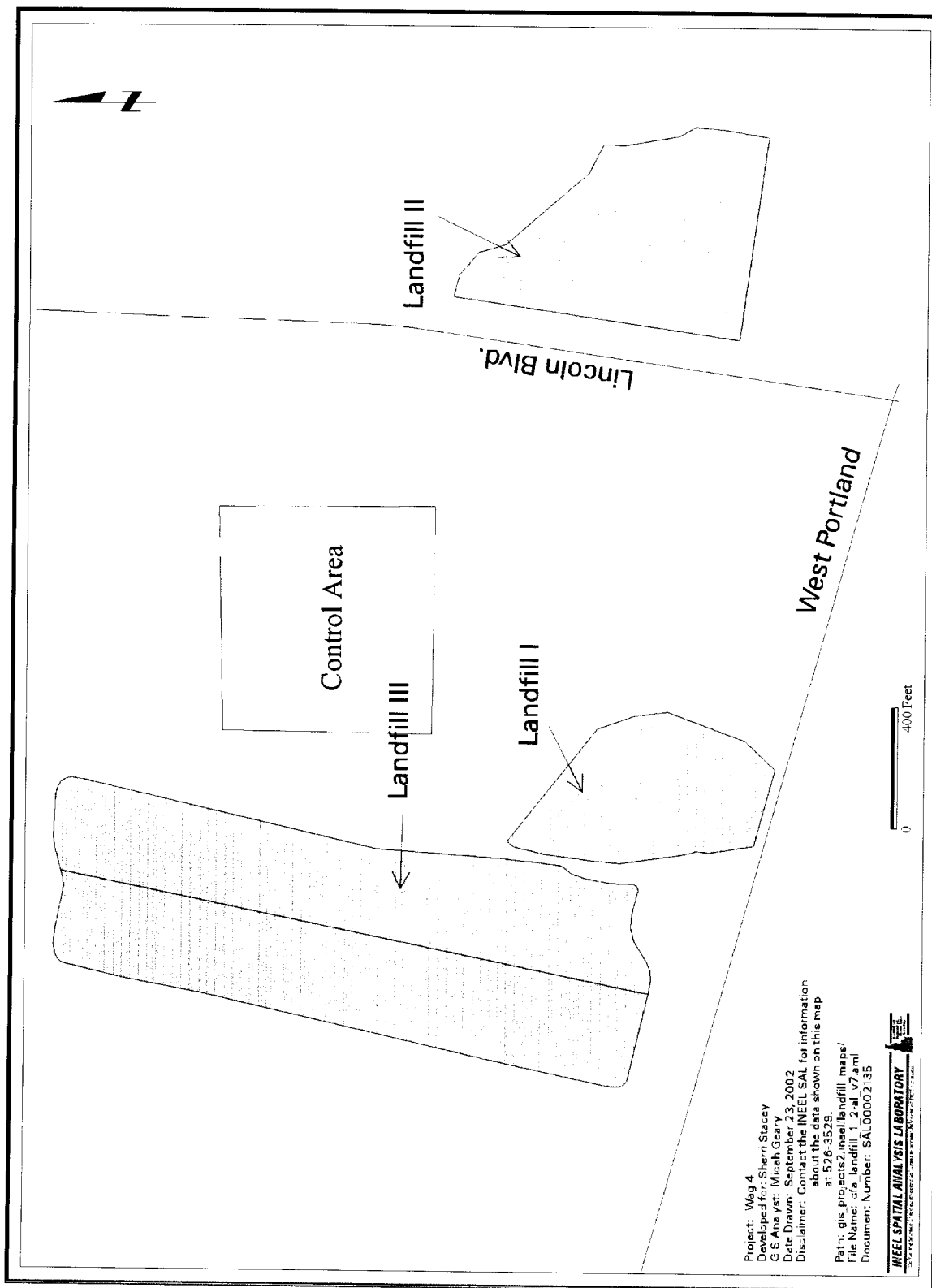


Figure 2-3. Landfills and control area in relation to the roads.

2.2.2 Landfill I

Landfill I occupied a total surface area of approximately 3.3 ha (8.25 acres) and consisted of three subunits: the rubble landfill, western waste trench, and northern waste trench.

The rubble landfill originated as a gravel quarry that the U.S. Navy operated from 1942 to 1949. The INEEL used the quarry as a Sitewide waste disposal area from the 1950s until 1984. The surface area of the rubble landfill was approximately 2.2 ha (5.5 acres), and its depth was 3.7 to 4.6 m (12 to 15 ft). To close the rubble landfill, the INEEL covered it with approximately 0.3 to 1.2 m (1 to 5 ft) of soil overlain with a layer of gravel.

The western waste trench covered approximately 0.81 ha (2 acres). It consisted of smaller waste trenches, approximately 15 x 2.4 x 3 m (50 x 8 10 ft), that were separated by 4.6 m (15 ft) of undisturbed soil. As each trench filled with waste, workers covered them with 0.3 to 1.5 m (1 to 5 ft) of soil. Because of the location of the western waste trench, during remedial efforts this trench was included under the compacted soil barrier placed over Landfill III.

Information pertaining to the northern waste trench's true dimensions was limited, and it was covered with soil and was not discernible at the surface. So the INEEL identified it from aerial photographs and calculated its surface area to be approximately 0.3 ha (0.75 acres).

2.2.3 Landfill II

Landfill II encompassed approximately 6.1 ha (15 acres) in the southwest corner of an abandoned gravel pit. It received waste from September 1970 until September 1982. Depth to basalt at the landfill varied from 4.6 to 11.3 m (15 to 37 ft) based on a seismic refraction survey and a subsurface borehole drilling investigation. The landfill waste profile, however, was estimated to range in depth from 3.7 to 8.5 m (12 to 28 ft), because the pit probably was not excavated beyond the base of the gravel-bearing unit and into the clay material. Hand augering at 60 sampling sites indicated that the original Landfill II soil cover ranged in thickness from 0.1 to 1.0 m (0.33 to 3.17 ft), with an overall mean of 0.47 m (1.5 ft). The landfill surface was gently undulating due to differential settling of the waste and it maintains a stand of crested wheatgrass.

2.2.4 Landfill III

Landfill III consisted of six trenches that covered approximately 4.9 ha (12 acres). It opened after Landfill II closed in September 1982 and operated until December 1984. Depth to the underlying basalt is 3 to 10 m (10 to 33 ft) based on a seismic refraction survey. The landfill waste profile was estimated to be 4 m (13 ft) deep on average. It was common practice to excavate the landfill trenches, leaving a soil layer intact between the wastes and underlying basalt. The original Landfill III soil cover ranged in thickness from 0.3 to 2.4 m (1 to 8 ft) with an overall mean of 0.86 m (2.83 ft), based on augering results. Ground-penetrating radar measurements estimated the average original soil cover thickness to be 0.6 to 0.9 m (2 to 3 ft). The landfill surface was also gently undulating due to differential settling of the waste and it maintains a stand of crested wheatgrass.

3. REMEDIAL ACTION AT THE CENTRAL FACILITIES AREA LANDFILLS I, II, AND III

The remedial action conducted at CFA Landfills I, II, and III is protective of human health and the environment and in compliance with the applicable or relevant and appropriate requirements (ARARs) as established in the Record of Decision (ROD) (DOE-ID 1995).

3.1 Remedy Implementation

The remedial action for CFA Landfills I, II, and III included placement of a native soil cover, establishment of environmental monitoring, implementation of administrative controls, inspection and maintenance of the cover, and maintenance of institutional controls. The remedial action commenced in 1996 with completion of the installation of the monitoring equipment in April 1997. A new time-domain reflectometer array, which is used for monitoring soil moisture, was installed in 2000 and became operational in October of that year.

The native soil cover consisted of three layers: (1) a general backfill layer that brought the existing grade up to the design slope (rough grade), (2) a compacted low-permeability soil layer, and (3) a topsoil layer that created the final grade and allows for growth of a vegetative cover. To install the cover over each landfill, the landfill was initially grubbed to remove surficial organic material in an effort to minimize void creation due to decomposition. Fill material for all three layers was obtained from Spreading Area "B" at the INEEL and placed over the landfills. The fill material was described as a lean clay with sand. The particle size analysis had 84.1% of the material passing through a No. 200 sieve (less than 0.075 mm average diameter). Both the general backfill and low-permeability soil layers were compacted to 95% of maximum dry density at 0 to +4 percentage points from optimum moisture content. The general backfill layer was emplaced with a maximum 15-cm (6-in.) compacted lift thickness. The low-permeability soil layer was placed in maximum 20-cm (8-in.) loose lifts to attain a maximum 15-cm (6-in.) compacted lift thickness. The final topsoil layer was emplaced with no compaction. The resulting native soil covers at the CFA landfills (in combination with the existing soil cover) were at the minimum 2 ft in depth. In addition, for Landfill II, a riprap layer was installed at the extreme northeast face of the landfill, rather than revegetating the area, in an effort to prevent erosion due to the steepness of the slope. A detailed description of the remedial action, including the installation of the landfill covers, is provided in the *Remedial Action Report CFA Landfills I, II, and III Native Soil Cover Project Operable Unit 4-12* (DOE-ID 1997).

3.1.1 Plants Used to Revegetate the CFA Landfills

Following remedial efforts in 1994, CFA Landfill III was seeded with streambank wheatgrass (*Agropyron riparium*), needle and thread grass (*Stipa comata*), Indian rice grass (*Oryzopsis hymenoides*), flax (*Ademolimun lewisii*), fern-leaved desert parsley (*Lomatium dissectum*), Wyoming big sagebrush (*Artemisia tridentate*), and, in some sections, winterfat (or white sage) (*Ceratoides lanata*). All these plant species were chosen for revegetation because they were native to the area. The final remedial action took place in 1996 with the CFA landfills being capped with a compacted soil barrier. Then all three CFA landfills were revegetated with crested wheatgrass (*Agropyron cristatum*), Siberian wheatgrass (*Agropyron sibiricum*), and thickspike wheatgrass (*Agropyron dasystachyem*) in the fall of 1996. These plant species did not entirely displace those plant species planted in 1994.

4. JUSTIFICATION

The 2002 SAT characterized burrowing mammals and vegetation present on the compacted soil barriers at CFA Landfills I, II, and III. The purpose was to provide more information for assessing long-term threats to the barrier integrity. If the burrowing mammals and vegetation are compromising the barrier's integrity then water could percolate through the protective barriers, leach through the waste, and migrate contaminants in the aquifer. In addition to the CFA landfills, the SAT selected a control area to evaluate successional activities and identify small mammal population differences from those identified on the landfills.

Small mammals could affect the compacted soil barriers by creating passageways, through their burrowing systems, for moisture to move more readily down into the buried waste. These passageways may also penetrate down into the waste so that the small mammals may be exposed themselves or bring contamination to the surface. Small mammals inhabiting the CFA landfills are likely to be influencing the integrity of the compacted soil barriers through these process, given that small mammals most commonly seen on the CFA landfills have been known to burrow up to 0.61 m (2 ft) in depth. The compacted soil barriers at the CFA landfills range from 61 to 76 cm (2 to 2.5 ft) in depth. For this reason, the SAT will evaluate potential effects from small mammals and their burrows on the CFA landfill native soil barriers.

Noxious weeds and native shrubs can threaten the integrity of the compacted soil barriers by displacing desirable grasses. In addition, their extensive deep-burrowing root systems may penetrate the buried waste and transport contaminants to the surface. Decomposing root systems may leave channels for water and vapors to infiltrate through the compacted soil barrier to the buried waste zone. Additionally, root systems may dry clay layers, causing shrinking and cracking, which could also increase water infiltration. The roots of alfalfa (*Medicago sativa*), a commonly found plant species on CFA Landfill III, has been shown to reach depths up to 2 m (6.6 ft). Vegetation surveys will be used by the SAT to evaluate vegetation growing on the CFA landfill compacted soil barriers and possible influences it may be having on the performance of the barriers.

5. OBJECTIVES

The 2002 SAT developed the following objectives to obtain data for evaluating the potential effects that burrowing mammals and vegetation may have on the compacted soil barriers at CFA Landfills I, II, and III. These objectives include the following:

1. Characterize and assess small mammal populations on the landfills
2. Characterize small mammal burrowing depths
3. Characterize and assess the vegetative cover on the landfills
4. Characterize plant rooting depths
5. Identify current successional activities on the landfills.

These objectives will help to characterize the CFA landfills, and were obtained by the following activities:

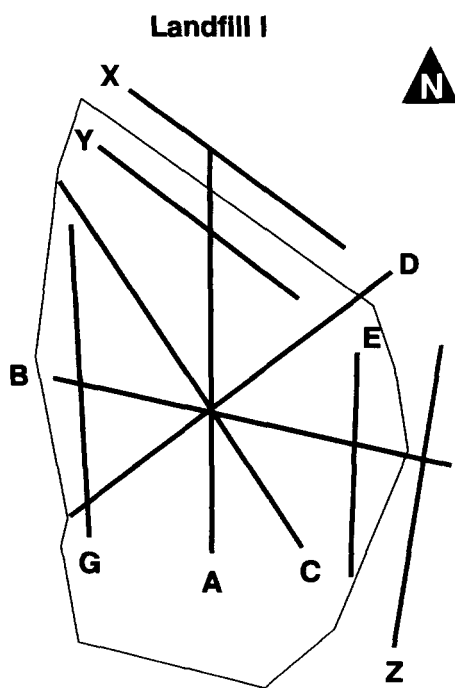
- Identifying small mammal species and their population using capture-recapture methods and the Peterson-Lincoln index
- Determining burrowing depths of species captured on the CFA landfills through a literature search
- Identifying small mammal species in a control area to determine if there are any differences from those caught in the CFA landfills
- Identifying plant species located on the CFA landfills
- Identifying plant species in the control area for indication of the potential successional activities on the CFA landfills
- Applying techniques for quantifying plant cover and frequency using the Line Intercept and Daubenmire methods
- Comparing observed vegetation species to those planted and the areas most affected by successional activities
- Determining root depth of most common plant species identified on landfills and the control area through a literature search.

6. METHODS

6.1 Trapping Small Mammals

The CFA Landfill I covers approximately 3.3 ha (8.25 acres). West Portland Avenue (a paved road) borders the south side of the landfill and a gravel road borders the west side. Sagebrush is encroaching beyond the fence boundary on the east side of the landfill and the north side has meager amounts of sagebrush and gravel. Crested wheatgrass is the prominent plant species on this landfill. The SAT used Sherman traps for trapping small mammals at all locations. The SAT established nine transect lines on Landfill I with small mammal traps spaced 10 m (35 ft) apart; transect lines A, B, C, D, E, and F had 20 traps, transect line G had 10 traps, and transect lines X, Y, and Z each had 15 traps. The position of these transect lines are shown in Figure 6-1. The transect line design was aimed to detect any small mammals entering or residing on the landfill.

The CFA Landfill II covers approximately 6 ha (15 acres). A dirt road borders the south side of the landfill and meager amounts of sagebrush and gravel border the east side. Approximately 15 m of sagebrush border the west side of the landfill before it meets Lincoln Boulevard. The north side has riprap along the west corner and a new parking lot being built near the northeast end. Crested wheat grass is the prominent plant species on this landfill. The SAT placed seven transect lines on this landfill with capture stations, near or on the fence line, spaced 10 m (35 ft) apart. Transect line A had 32 traps, transect line B had 28 traps, transect line C had 20 traps, transect line D, E, and F all had 15 traps, and transect line G had 3 traps. The transect lines located nearer to the center of the landfill had capture stations spaced 15 meters (45 feet) apart. The position of these transect lines are shown in Figure 6-2. The reason for this trapping design was due to the vegetation growth patterns found on this landfill. The vegetation is sparse in the center of the landfill and is more abundant along the fencelines. This trap design was chosen because it allowed for detection of small mammal movement off or onto the landfill from surrounding areas.



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Figure 6-1. The layout of the transect lines on CFA Landfill I.

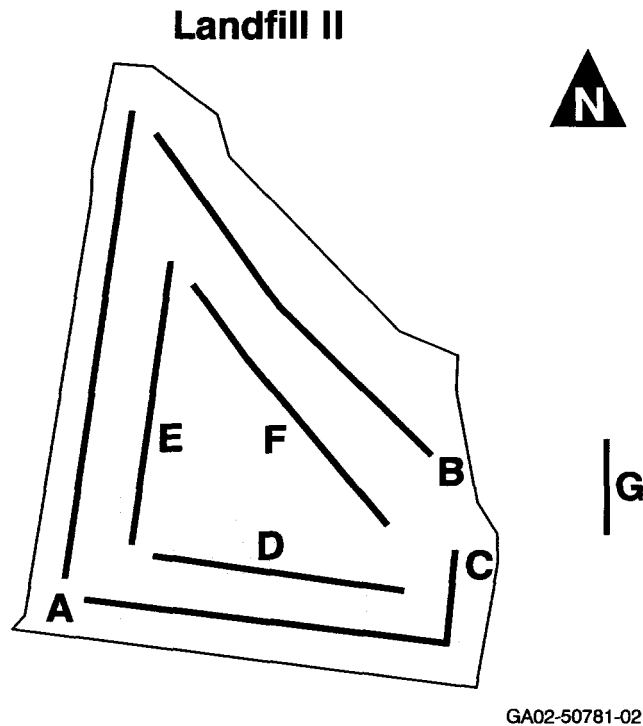
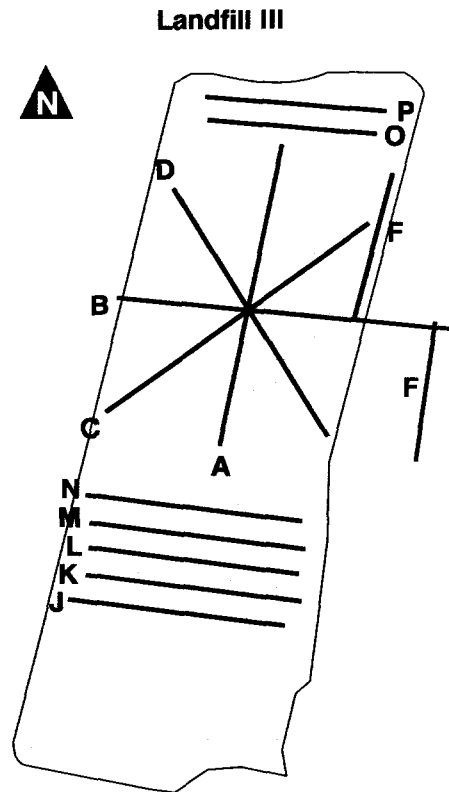


Figure 6-2. The layout of the transect lines on CFA Landfill II.

The CFA Landfill III covers approximately 5 ha (12.5 acres). Approximately 16 m of sagebrush borders the south side of the landfill before it meets West Portland Avenue. A gravel road borders the east side and the west end is located near a new landfill under construction. The trench for the new landfill creates a steep ledge along the length of Landfill III. A gravel road borders the north side. Crested wheatgrass is the prominent plant species on this landfill.

The SAT established twelve transect lines with capture stations spaced 10 m (35 ft) apart. Transect lines A, B, C, D each had 18 traps, and transect line F had 20 traps. Transect line J had 8 traps and transect lines K, L, M, N, O, and P all had 5 traps (see Figure 6-3). The SAT set up the transect lines to capture small mammals entering or residing on the north side of Landfill III. A gravel road is all the separated the south end of Landfill III from Landfill I To limit overlap between these two trapping locations, and to reduce recapturing small mammals from Landfill I on Landfill III, the SAT set up transect lines only on the north end of Landfill III. This set up also helped the SAT to identify differences in the small mammal species on the two landfills. The long narrow north end of Landfill III contains more vegetation along the sides than in the center. This landfill has the largest variety of vegetation as compared to the other two landfills.

The control area is located east of CFA Landfill III and north of Landfill I. The control area has the largest variety of vegetation, and big sagebrush is the prominent plant species. The vegetation in the control area contains more native plant species and is a more suitable habitat for an assortment of small mammal species. The control area should contain the largest variety of small mammal species, and the SAT chose it to evaluate all possible small mammal species located near the CFA landfills. The soil disturbance in the control area is more limited than that in the three CFA landfills; however, it has more anthills than any of the three CFA landfills. The ant species occupying these anthills are Harvester Ants (*Pogonomyrmex salinus*). Harvester ants build medium to large sized mounds up to 0.3 to 1.2 m (1 to 4 ft) across, and 5.1 to 25.4 cm (2 to 10 in.) high. The harvester ants not only construct large mounds, which cause loss of grass, but also clear areas of grass around the nest and along the forage trails radiating



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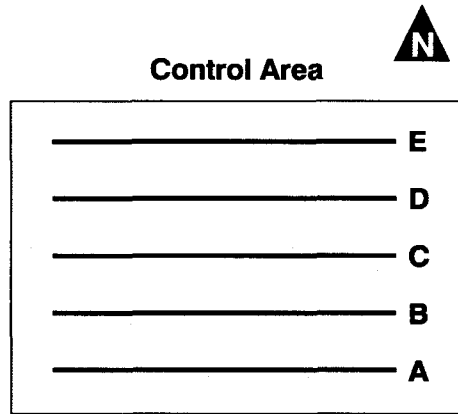
Figure 6-3. The layout of the transect lines on CFA Landfill III.

from the central nest. Cleared areas around the nest may be 7 m (23 ft) or more in diameter. Harvester ants tunnel up to 4.6 m (15 ft) down when building their colony and may have many thousands of ants per colony (Parramon 1991).

Transect lines A, B, C, and D ran parallel west to east and each contained 20 evenly spaced traps (see Figure 6-4). The SAT designed this transect so they could evaluate the variety of small mammal species located near the landfills.

For each of the four areas, Landfills I, II, III, and the control area, the SAT use a two-week trapping period to determine the recapture percentages. The SAT set small mammal traps in late afternoon, before concluding fieldwork and checked them first thing in the morning. Each capture station, marked with a numbered flag, contained one live-capture Sherman small mammal trap, which was baited with a mixture of peanut butter, molasses, and oats.

Because the bait could have been attracting small mammals from the surrounding areas and not just those nesting on or near the CFA landfills, the population size estimates will include small mammal species located on the CFA landfills and the surrounding areas. However, the grasses and forbs on the CFA landfills are a good food source for many small mammals and small mammals that nest in surrounding areas may use existing burrows or create new burrows on the landfills for food storage.



GA02-50781-01

Figure 6-4. The layout of the transect lines on the control area.

6.1.1 Methods for Determining Small Mammal Populations

Small mammal populations were determined using capture-recapture methods and the Peterson-Lincoln Index. The basis of the capture-recapture method is that one catches a random sample of a population, marks individuals, releases them so they remix with the rest of the population, and then catches a second random sample that bears a mark from the first capture period. Generally speaking, if the population is large, the marked individuals will have become diluted within it, and only a few would be expected to appear in the second sample. If assumptions about the sampling and animal's distribution are correct, then the proportion of marked individuals in the second sample is the same as that in the entire population. Captured small mammals were marked with a distinct color of either Kool-Aid® or nail polish for each day of the week. In addition to marking each small mammal, the SAT identified the species, and weighed and measured each individual.

The SAT used the Peterson-Lincoln Index to estimate the total population by assuming the total population size to be estimated contains N individuals. From this population, M individuals are marked and returned to the population. At a later time, a sample of n individuals needs to be captured from the population; this sample contains R recaptured animals (i.e., individuals captured and marked in the first sampling). Then the population size, N , may be estimated using the following equation:

$$N = Mn / R \quad (1)$$

However, Equation 1 overestimates the population size (i.e., it is biased) when the samples are relatively small (Chapman 1951). N_c is a nearly unbiased estimate of population size if the number of recaptured animals, R , is at least 8 (Krebs 1989). The SAT reduced this bias by using the following equation:

$$N_c = \frac{(M + 1)(n + 1) - 1}{R + 1} \quad (2)$$

The approximate variance, s^2 , of this estimate is:

$$s^2 = \frac{(M + 1)(n + 1)(M - R)(n - R)}{(R + 1)^2 (R + 2)} \quad (3)$$

With the standard deviation, s , 95% and 99% confidence limits on the population estimate are given by:

$$N(\text{or } N_c) + 1.96(s) \text{ (95\% confidence limits)} \quad (4)$$

and

$$N(\text{or } N_c) + 2.58(s) \text{ (99\% confidence limits)} \quad (5)$$

Section 7.2 presents the results of the small mammal population studies, and includes an inventory of the small mammal species captured for those small mammal species caught into few a number to calculate the population size.

6.2 Vegetation Density and Cover Analysis

Two methods, the line-intercept method and the Daubenmire method, were used to estimate the percent cover of plant species on the CFA Landfills I, II, III and the control area. Both methods result in good estimates of percent cover in areas where vegetation is limited. The SAT also used data from the Daubenmire method to determine the percent frequency of each plant species. The following sections provide a description of the line intercept method and the Daubenmire method. Section 7.4 presents the results of the vegetation density and cover analysis.

6.2.1 Line Intercept Method

A 50-foot string marked every inch was stretched between two stakes. The string served as a tape measure for each vegetation line. Vegetation lines were spaced 50 feet apart and ran south to north down the center of each of the CFA landfills. On Landfill I and II vegetation lines also ran east to west. Landfill I had 18 vegetation lines running north to south and 10 vegetation lines running east to west. Landfill II had 16 vegetation lines running north to south and 14 vegetation lines running east to west. Landfill III had 48 vegetation lines running north to south. East to west lines were not done on Landfill III because it was long and narrow. The control area had 18 vegetation lines running south to north. The intercept distance was recorded for each plant/species that intercepted the line. The accumulated length for any species divided by the total length of all vegetation lines multiplied by 100 was expressed as the total percent cover for that plant species.

6.2.2 Daubenmire Method

A 50 by 100 cm quadrant was used to estimate percent ground cover using the Daubenmire method. Canopy cover was visually estimated as a vertical projection of a polygon drawn around the extremities of each plant. The projections were summed and recorded for a corresponding cover class. Six cover classes were used and converted to class midpoints for data analysis. Table 6-1 shows the midpoint percentages for the six cover classes used. For placement of the quadrant on Landfill I, the SAT systematically selected 40 random locations along vegetation lines spaced 25 ft apart. Using the same selecting system, the SAT placed 60 quadrants at Landfill II, 156 at Landfill III, and 40 in the control area. An average of the class mid-points was used to determine the total percent cover for each plant species.

Table 6-1. Vegetation cover classes for the Daubenmire method.

Coverage Class	Range of Coverage (%)	Midpoint of Range (%)
1	0–5	2.5
2	6–25	15.0
3	26–50	37.5
4	51–75	62.5
5	76–95	85.0
6	95–100	97.5

7. RESULTS

7.1 Small Mammals Captured on the CFA Landfills and the Control Area

The 2002 SAT identified seven small mammal species on CFA Landfills I, II, and III, and the control area. Small mammal species captured on each landfill are listed in the Table 7-1. The traps placed near sagebrush, rocky outcrops, fence lines, or areas with larger amounts of vegetation had the highest percentage of captures because these areas provided the most cover and suitable habitat. CFA Landfill II contained the largest number of small mammals, consisting mainly of deer mice and CFA Landfill III had the largest variety of small mammals. Deer mice, along with the Great Basin pocket mouse, were the most commonly captured species. The least chipmunk was only captured in small mammal traps placed near or just outside the fence line of CFA Landfill I.

Table 7-1. Total small mammal species captured on each of the trapping locations.

Small mammal species	CFA Landfill I	CFA Landfill II	CFA Landfill III	Control Area
Deer Mouse (<i>Peromyscus maniculatus</i>)	17	58	15	18
Great Basin Pocket Mouse (<i>Perognathus parvus</i>)	11	—	3	2
Montane Vole (<i>Microtus montanus</i>)	1	1	2	—
Least Chipmunk (<i>Eutamias minimus</i>)	4	—	—	6
Townsend Ground Squirrel (<i>Spermophilus townsendii</i>)	—	—	3	—
Ord's Kangaroo Rat (<i>Dipodomys ordii</i>)	—	10	—	—
Richardson's Ground Squirrel (<i>Spermophilus richardsonii</i>)	—	—	2	—
Long-tailed Pocket Mouse (<i>Perognathus formosus</i>)	—	1	—	—
Total Number of Species	33	70	25	26

7.1.1 Analysis of Small Mammals Captured on CFA Landfill I, II, III, and the Control Area

There were 33 small mammals captured on CFA Landfill I. Of this total, 52% were deer mice, 33% were Great Basin pocket mice, 12% were least chipmunks, and 3% were Montane voles (see Figure 7-1). The greatest numbers of small mammals were captured along the east fence line. Lined by sagebrush, this side of the landfill was both a suitable habitat and a good entrance point for small mammals to enter the landfill. .

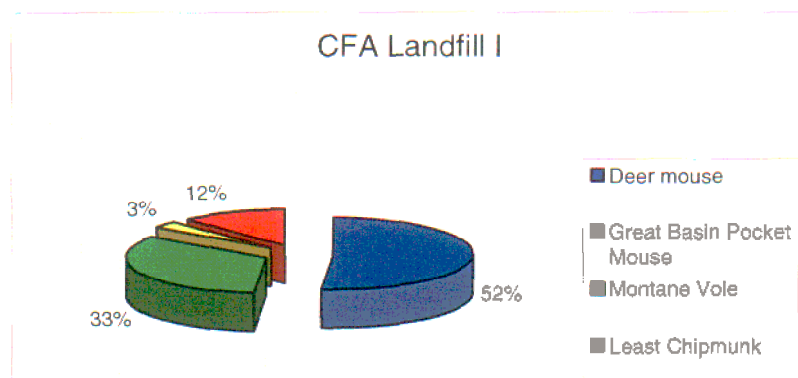


Figure 7-1. The percentage of each small mammal captured on CFA Landfill I.

There were 70 small mammals captured on CFA Landfill II. Of this total, 84% were deer mice, 14% were Ord's kangaroo rats, 1% were montane voles, and 1% were long-tailed pocket mice (see Figure 7-2). The greatest numbers of small mammals were captured along the north and east fence lines. Lined by riprap, the north side of the landfill provided suitable habitat and a good entrance point for small mammals. The western border of the landfill had about 100 feet of vegetation before it hit a main road (Lincoln Blvd). Several small mammal burrows were found located next to the road.

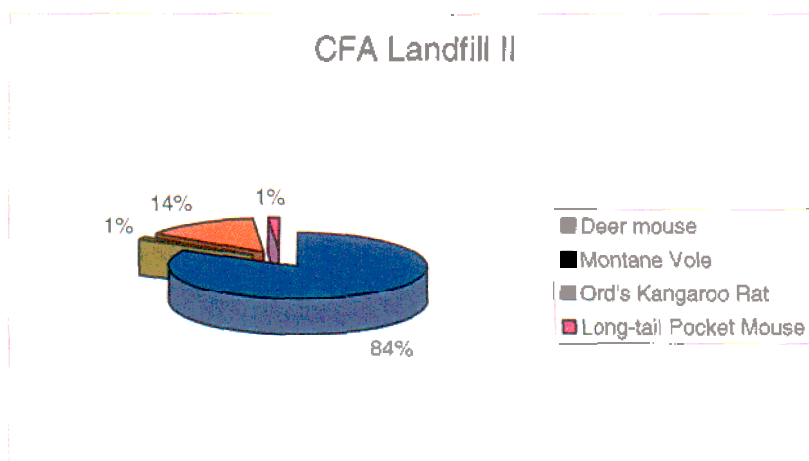


Figure 7-2. The percentage of each small mammal captured on CFA Landfill II.

There were 25 small mammals captured on CFA Landfill III. Of this total, 60% were deer mice, 12% were Great Basin pocket mice, 12% were Townsend's ground squirrels, 8% were Montane voles, and 8% were Richardson's ground squirrels (see Figure 7-3). Small mammals were more randomly caught on this landfill. The transect line placed just outside of Landfill III (transect line F) along the sagebrush, only had a couple of captures.

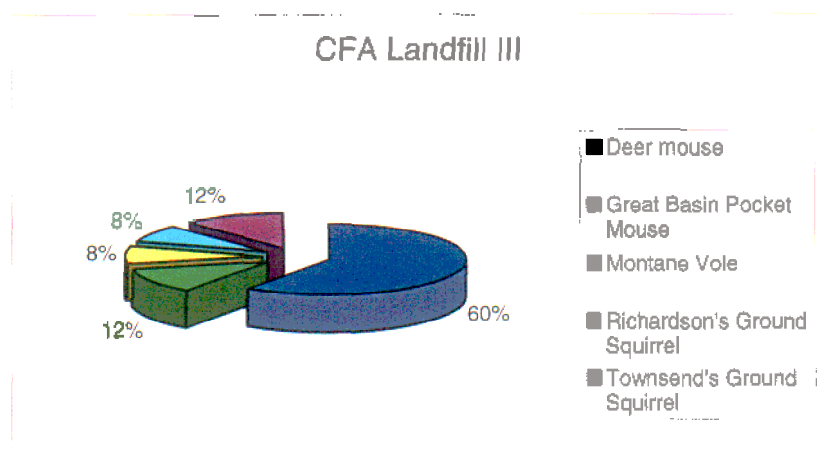


Figure 7-3. The percentage of each small mammal captured on CFA Landfill III.

There were 26 small mammals captured on the control area. Of this total, 69% were deer mice, 23% were least chipmunks, and 8% were Great Basin pocket mice (see Figure 7-4). Small mammals were randomly caught on this area and no one spot was more popular. While checking the small mammal traps several harvester ants were found transporting the bait out of the traps. The large number of ants in the control area may have lessened the incentive for small mammals to enter the traps.

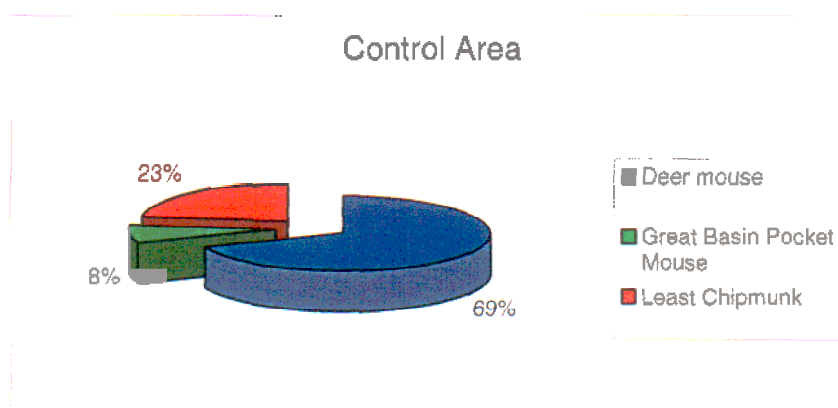


Figure 7-4. The percentage of each small mammal captured on the control area.

7.2 Small Mammal Populations

Small mammal populations were determined using capture-recapture methods and the Peterson-Lincoln Index. The two best trapping days of the two-week trapping period at each landfill were selected to determine the small mammal populations. The first day selected represented the total number of small mammals caught and marked. The second day represented a percentage of recaptured small mammals. Section 6.1.1 presents the Lincoln-Peterson Index method used to calculate the small mammal populations. The following sections discuss the results of the small mammal population calculations at CFA Landfills I, II, III, and the control area. Appendix D presents the inventory of all captured small mammals.

7.2.1 CFA Landfill I Small Mammal Populations

The small mammals captured on CFA Landfill I included the deer mouse, Montane vole, least chipmunk, and the Great Basin pocket mouse. The estimated small mammal populations for Landfill I are listed in Table 7-2. The deer mouse had the largest estimated population at 27 (49 with a 95% confidence limit and 56 with a 99% confidence limit) and the Great Basin pocket mouse had the second highest at 11 (17 with a 95% confidence limit and 19 with a 99% confidence limit). The sample size for the Montane vole was too small to use the Lincoln-Peterson Index to determine the population size. The trapping timeframe for this landfill was during a full moon and very hot and dry weather, which may have had an effect on the capture success and may have decreased the activity of the small mammals. Using the population estimates, the total number of small mammals per square foot for CFA Landfill I was 1.17E-04.

Table 7-2. The population size of small mammals captured at all trapping locations on CFA Landfill I.

Small Mammal Species	Marked	Recaptured ^a	Population Size	95% Confidence Limit	99% Confidence Limit
Deer Mouse	5	1	27	48.5	55.5
Great Basin Pocket Mouse	4	2	11	16.8	18.5
Least Chipmunk	2	1	4	5.7	6.2
Montane Vole	1	0	NA	NA	NA

NA = Not Applicable, The sample size was too small to determine the population for this small mammal species.

a. If the number of small mammal species recaptured was less than 8 then the population size may be overestimated (Krebs 1989).

7.2.2 CFA Landfill II Small Mammal Populations

The small mammals captured on CFA Landfill II included the deer mouse, Ord's kangaroo rat, Montane vole, and long-tailed pocket mouse. The estimated small mammal populations for Landfill II are listed in Table 7-3. The deer mouse had the largest estimated population at 46 (60 with a 95% confidence limit and 64 with a 99% confidence limit) and the Ord's kangaroo rat had the second highest at 10 (16 with a 95% confidence limit and 18 with a 99% confidence limit). The sample size for the Montane vole and long-tailed pocket mouse was too small to use the Lincoln-Peterson Index to determine the population size. It rained a couple of times during the trapping period at this landfill, which may have influenced the capture success and increased the activity of small mammals. Using the population estimates, the total number of small mammals per square foot for CFA Landfill II was 8.57E-05.

Table 7-3. The population size of small mammals captured at all trapping locations on CFA Landfill II.

Small Mammal Species	Marked	Recaptured ^a	Population Size	95% Confidence Limit	99% Confidence Limit
Deer Mouse	23	9	46	59.6	64.1
Long-tailed Pocket Mouse	1	0	NA	NA	NA
Montane Vole	1	1	NA	NA	NA
Ord's Kangaroo Rat	3	1	10	15.7	17.7

NA = Not Applicable, The sample size was too small to determine the population for this small mammal species.

a. If the number of small mammal species recaptured was less than 8 then the population size may be overestimated (Krebs 1989).

7.2.3 CFA Landfill III Small Mammal Populations

The small mammals captured on CFA Landfill III included the deer mouse, Great Basin pocket mouse, Montane vole, Townsend's ground squirrel, and Richardson's ground squirrel. The small mammal populations for Landfill III are listed in Table 7-4. The deer mouse had the largest estimated population at 11 (27 with a 95% confidence limit and 32 with a 99% confidence limit) and the Great Basin pocket mouse had the second highest at 4 (5.4 with a 95% confidence limit and 5.9 with a 99% confidence limit). The sample sizes for the Montane vole, Townsend's ground squirrel, and Richardson's ground squirrel were too small to use the Lincoln-Peterson Index to determine the population size. Using the population estimates, the total number of small mammals per square foot for CFA Landfill III was 2.75E-05.

Table 7-4. The population size of small mammals captured at all trapping locations on CFA Landfill III.

Small Mammal Species	Marked	Recaptured ^a	Population Size	95% Confidence Limit	99% Confidence Limit
Deer Mouse	7	4	11	27	32
Great Basin Pocket Mouse	2	1	4	5.4	5.9
Montane Vole	2	0	NA	NA	NA
Richardson's Ground Squirrel	2	0	NA	NA	NA
Townsend's Ground Squirrel	3	0	NA	NA	NA

NA = Not Applicable, The sample size was too small to determine the population for this small mammal species.

a. If the number of small mammal species recaptured was less than 8 then the population size may be overestimated (Krebs 1989).

7.2.4 Control Area Small Mammal Populations

The small mammals captured in the control area included the deer mouse, Great Basin pocket mouse, and least chipmunk. The estimated small mammal populations for the control area are listed in Table 7-5. The deer mouse had the largest estimated population at 12 (16 with a 95% confidence limit and 17 with a 99% confidence limit) and the least chipmunk had the second highest at 4 (6 with a 95% confidence limit and 6 with a 99% confidence limit). The sample size for the least chipmunk was too small to use the Lincoln-Peterson Index to determine the population size.

Table 7-5. The population size of small mammals captured at all trapping locations on the control area.

Small Mammal Species	Marked	Recaptured ^a	Population Size	95% Confidence Limit	99% Confidence Limit
Deer Mouse	6	4	12	15.9	17.3
Great Basin Pocket Mouse	2	0	NA	NA	NA
Least Chipmunk	2	1	4	5.5	5.9

NA = Not Applicable, The sample size was too small to determine the population for this small mammal species.

a. If the number of small mammal species recaptured was less than 8 then the population size maybe overestimated (Krebs 1989).

7.3 Small Mammal Burrowing Depths

All the small mammals captured on the CFA landfills, as listed in Table 7-1, are burrowers. These species differ in their burrowing depths, but all have an impact on the compacted soil barriers. Burrows that penetrate the soil barrier into the waste may allow small mammals to transport contaminants to the surface or take contaminants into their systems. Burrows also create channels for water to seep down into the buried waste zone. The compacted soil barriers used at each of the CFA landfills range in thickness from 61 to 76 cm (24 to 30 in.). The compacted soil layer may limit the depth the small mammals may burrow; however, this layer is only 15 cm (6 in.) thick. Small mammal burrowing depths were not measured in the field but were found in a literature search of small mammal studies conducted on the INEEL. The results of the literature search are presented in Table 7-6.

Table 7-6. Maximum and average burrowing depths of the most common small mammals captured on the CFA landfills and the control area.

Small Mammal Species	Maximum Burrowing Depth (cm)	Reference	Average Burrowing Depth (cm)	Reference
Deer Mouse	50	Reynolds and Laundre (1988)	24	Reynolds and Wakkinen (1987)
Great Basin Pocket Mouse	61	Cline et al. (1982)	44.4	Landeen and Mitchell (1981)
Montane Vole	60	Reynolds and Laundre (1988)	23	Reynolds and Wakkinen (1987)
Least Chipmunk	31	Laundre (1989a)	17.5	Laundre (1989a)
Townsend's Ground Squirrel	140	Reynolds and Laundre (1988)	138	Reynolds and Wakkinen (1987)
Ord's Kangaroo Rat	61	Reynolds and Laundre (1988)	34	Reynolds and Wakkinen (1987)

Of the burrowing depths found in the literature, the Townsend's ground squirrel was deepest. The Townsend's ground squirrel is capable of burrowing through the compacted soil barrier into the buried waste. This species was captured on CFA Landfill III (where hazardous materials were disposed of; however, the sample size was too small to determine the population of the Townsend's ground squirrel on Landfill III).

The small mammal species with the next deepest burrowing depth were the Great Basin pocket mouse and the Ord's kangaroo rat. The average burrowing depths for these species are within 15 to 27 cm (6 to 11 in.) of the buried waste. The Great Basin pocket mouse was primarily captured on CFA Landfill I. The estimated population size for this species was 11 (17 with a 95% confidence limit and 19 with a 99% confidence limit). The Ord's kangaroo rat was only captured on CFA Landfill II, primarily along the north fence line and near the riprap. The estimated population for the Ord's kangaroo rat was calculated to be 10 (16 with a 95% confidence limit and 18 with a 99% confidence limit).

Although burrowing depths were not specifically measured on the CFA landfills, each time a new small mammal burrow was found the diameter of the opening (horizontally) was recorded. Table 7-7 list the number and diameter of small mammal burrows identified on CFA Landfills I, II, and III.

Table 7-7. Number of small mammal burrows observed on CFA Landfills I, II, and III.^a

Diameter of Small Mammal Burrows (cm), horizontally	Number of Small Mammal Burrows Observed on CFA Landfill I	Number of Small Mammal Burrows Observed on CFA Landfill II	Number of Small Mammal Burrows Observed on CFA Landfill III
1-2	1	8	5
2-3	26	28	74
3-4	39	30	73
4-5	35	33	60
5-6	10	7	35
6-7	16	5	18
7-8	1	2	12
8-9	4	1	6
9-10	1	2	1
10-11	—	—	3
11-12	1	—	—
12-13	1	—	1
14-16	1	1	—
25 and up	—	—	5
Total No.	136	117	293

a. More small mammal burrows may be present on the CFA landfills than the ones listed here because they were not easily observable.

The compacted soil barriers have a 5% grade around the outer perimeter of the CFA landfills. This sloped edge appears to be the prime location for burrowing activities.

CFA Landfill I contained nine anthills, mainly along the north fence line, a couple of rodent colonies in the center of the south end, and many burrows located long the fence lines. There were 136 small mammal burrows identified on Landfill I. Three of these burrow diameter's were greater than 11 cm (4.3 in.), when measured horizontally, but the majority were 3 to 5 cm (1.2 to 2 in.). Table 7-8 lists the average diameter of the burrows measured on the CFA landfills. Deer mice and the Montane vole both create burrows with diameters that range in the 3 to 5 cm (1.2 to 2 in.). Both of these species were captured in small numbers on Landfill I. The population of voles could not be estimated because the sample size was too small; however, the estimated population size of the deer mice was 27 (49 with a 95% confidence limit and 56 with a 99% confidence limit) and the estimated population size for the Great Basin pocket mouse was 11 (17 with a 95% confidence limit and 19 with a 99% confidence limit). A mammalogist who visited the site suspected a gopher dug the larger burrows. Pocket gopher burrows may reach a depth up to 97 cm (38 in.), but their tunnels typically remain about 15 cm (6 in.) below the surface (National Wildlife Federation 2002). Many of the small mammal burrows identified showed signs of erosion and age, and may not have been in use.

The CFA Landfill II contained one anthill, a couple of rodent colonies located in the center, and burrows located along the fence lines. Riprap on the northwest end of the barrier can provide burrows for mammals and reptiles. There were 117 small mammal burrows identified on Landfill II. Only one small mammal burrow was greater than 10 cm (3.9 in.) in diameter. The majority of small mammal burrows were 3 to 5 cm (1.2 to 2 in.) in diameter. Deer mice and Montane voles both create burrows with diameters in this range (see Table 7-8). Both of these species were captured on Landfill II. The sample size of voles was too small to estimate the population size. The estimated population size of the deer mice was 4 (60 with a 95% confidence limit and 64 with a 99% confidence limit). Few small mammal burrows were found in the 7 to 8 cm (2.8 to 3.2 in.) diameter range (3 total) although some Ord's kangaroo rats were captured on CFA Landfill II. The Ord's kangaroo rat was primarily captured along the north fence line near the riprap. The estimated population size for the Ord's kangaroo rat was 10 (16 with a 95% confidence limit and 18 with a 99% confidence limit). As compared with Landfill I, several of the small mammal burrows looked more recently made. This could account for the larger number of small mammals captured on this landfill.

CFA Landfill III contained a large number of mammal burrows around the perimeter of the compacted soil barrier, and five large mammal burrows along the west fence line. One anthill was observed at CFA Landfill III. There were 293 small mammal burrows identified on Landfill III. Badgers or coyotes could have made the five mammal burrows that were greater than 25 cm (9.8 in.) in diameter. Badgers have a burrowing depth of up to 231 cm (91 in.) (Long and Killingley 1983). The majority of

Table 7-8. The average and range of burrow diameters of small mammal species identified on the CFA Landfills.

Small Mammal Species	Average Burrow Diameter, Horizontally (cm) ^a	Range of Burrow Diameters, Horizontally (cm) ^a
Deer mouse	6.1	1.9 to 10.5
Least Chipmunk	7.5	6.5 to 8.7
Montane Vole	4.3	1.1 to 7.3
Ord's Kangaroo Rat	7.6	5.7 to 13.2
Townsend's Ground Squirrel	8	6.5 to 9.6

a. The average and range of diameters for the small mammal burrows was taken from Laundre (1989b).

small mammal burrows observed on Landfill III were 2 to 5 cm (0.8 to 1.2 in.) in diameter. Deer mice and Montane voles both create burrows in this diameter range (see Table 7-8). Both of these species were captured on Landfill III. The sample size of voles was too small to estimate the population size. The estimated population size of the deer mice was 11 (27 with a 95% confidence limit and 32 with a 99% confidence limit) and the estimated population size for the Great Basin pocket was 4 (5 with a 95% confidence limit and 6 with a 99% confidence limit). Many of the small mammal burrows identified along the west fence line showed signs of erosion and age, and may no longer have been in use.

7.4 Vegetation Surveys

Both the Daubenmire and the Line-Intercept methods were used to assess the percent cover and frequency of each plant species located in the CFA Landfill I, II, III, and the control area east of Landfill III. Thirty-seven plant species were identified on CFA Landfills I, II, and III and twenty-six plant species were identified in the control area during the vegetation surveys. Plant species identified in the CFA landfills included the following:

- Alfalfa (*Medicago sativa*)
- Balloon Flower (*Penstemon palmeri*)
- Bigbract Verbena (*Verbena bracteata*)
- Bluebunch Wheatgrass (*Pseudoroegneria spicata*)
- Canadian Thistle (*Cirsium arvense*)
- Cheatgrass (*Bromus tectorum*)
- Crested Wheatgrass (*Agropyron cristatum*)
- Crossflower (*Chorispora tenella*)
- Curly Dock (*Rumex crispus*)
- Dandelion (*Taraxacum officinale*)
- Flax (*Adenolinum lewisii*)
- Foxtail Barley (*Hordeum jubatum*)
- Fremont's Goosefoot (*Chenopodium fremontii*)
- Globemallow (*Sphaeralcea munroana*)
- Gray Rabbitbrush (*Chrysothamnus nauseosus*)
- Great Basin Wild Rye (*Elymus cinereus*)
- Green Rabbitbrush (*Chrysothamnus viscidiflorus*)

- Halogeton (*Halogeton glomeratus*)
- Indian Rice Grass (*Oryzopsis hymenoides*)
- Kochia (*Kochia scoparia*)
- Locoweed (*Astragalus purshii*)
- Musk Thistle (*Carduus nutans*)
- Pepperweed (*Lepidium densiflorum*)
- Prickly Wild Lettuce (*Lactuca serriola*)
- Russian Thistle (*Salsola kali*)
- Sagebrush (*Artemisia tridentata*)
- Silvery Lupine (*Lupinus argenteus*)
- Smooth Brome (*Bromus tectorum*)
- Spiny Skeleton Weed (*Lygodesmia spinosa*)
- Thickspike Wheatgrass (*Agropyron dasystachyum*)
- Threadstalk Milkvetch (*Astragalus filipes*)
- Western Salsify (*Tragopogon dubius*)
- Western Tansy Mustard (*Descurainia pinnata*)
- White Clover (*Trifolium repens*)
- White Top (*Cardaria draba*)
- Yarrow (*Achillea millefolium*)
- Yellow Sweetclover (*Melilotus officinalis*).

Plant species identified in the control area include the following:

- Balloon Flower (*Penstemon palmeri*)
- Cheatgrass (*Bromus tectorum*)
- Crested Wheatgrass (*Agropyron cristatum*)
- Foxtail Barley (*Hordeum jubatum*)

- Franklin's Sandwort (*Arenaria franklinii*)
- Gray Rabbitbrush (*Chrysothamnus nauseosus*)
- Green Rabbitbrush (*Chrysothamnus viscidiflorus*)
- Hoary Aster (*Machaeranthera canescens*)
- Hoary False Yarrow (*Chaenactis douglasii*)
- Indian Rice Grass (*Oryzopsis hymenoides*)
- Kochia (*Kochia scoparia*)
- Long-Leaf Phlox (*Phlox longifolia*)
- Longleaved Hawksbeard (*Crepis acuminata*)
- Needle and Thread Grass (*Stipa comata*)
- Oval-Leaf Buckwheat (*Eriogonum ovalifolium*)
- Pepperweed (*Lepidium densiflorum*)
- Prickly Pear Cactus (*Opuntia polyacantha*)
- Prickly Phlox (*Leptodactylon pungens*)
- Russian Thistle (*Salsola kali*)
- Sagebrush (*Artemisia tridentata*)
- Shaggy Fleabane (*Erigeron pumilus*)
- Shrubby Buckwheat (*Eriogonum microthecum*)
- Smooth Brome (*Bromus tectorum*)
- Thickspike Wheatgrass (*Agropyron dasystachyum*)
- Threadstalk Milkvetch (*Astragalus filipes*)
- Western Tansy Mustard (*Descurainia pinnata*).

Some of the plants originally identified on CFA Landfill I, II, and III as alfalfa had white flowers instead of purple flowers, and were later determined to be white clover. White clover plants were a lot less common than the alfalfa plants; however, because the color of the flower was not recorded during the vegetation studies white clover was grouped with the alfalfa.

7.4.1 Results of the Vegetation Surveys on CFA Landfill I

On CFA Landfill I, crested wheatgrass had the highest percent cover. Using the Daubenmire method, the percent cover for crested wheatgrass was 24% and by the line-intercept method, the percent cover was 18% (see Figures 7-5 and 7-6). Immature wheatgrass and alfalfa were the next plant species with the highest percent of cover for the landfill, at 7 and 4%, respectively, by the Daubenmire method. Using the line-intercept method, cheatgrass, immature wheatgrass, and thickspike wheatgrass were the next plant species with the highest percent cover at 4, 3, and 3%, respectively.

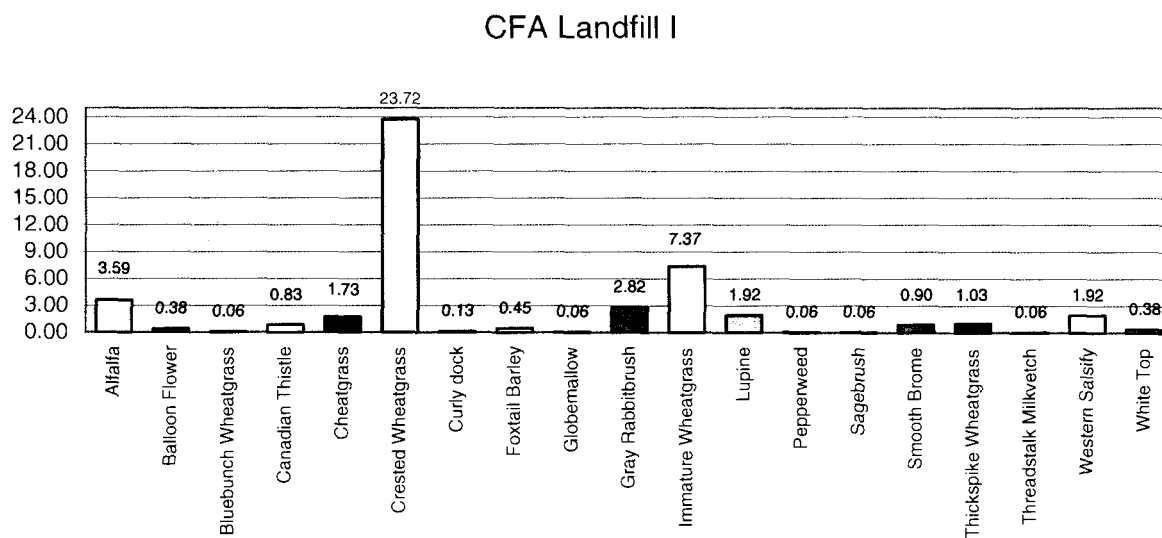


Figure 7-5. Percent cover of all plant species surveyed on CFA Landfill I using the Daubenmire method.

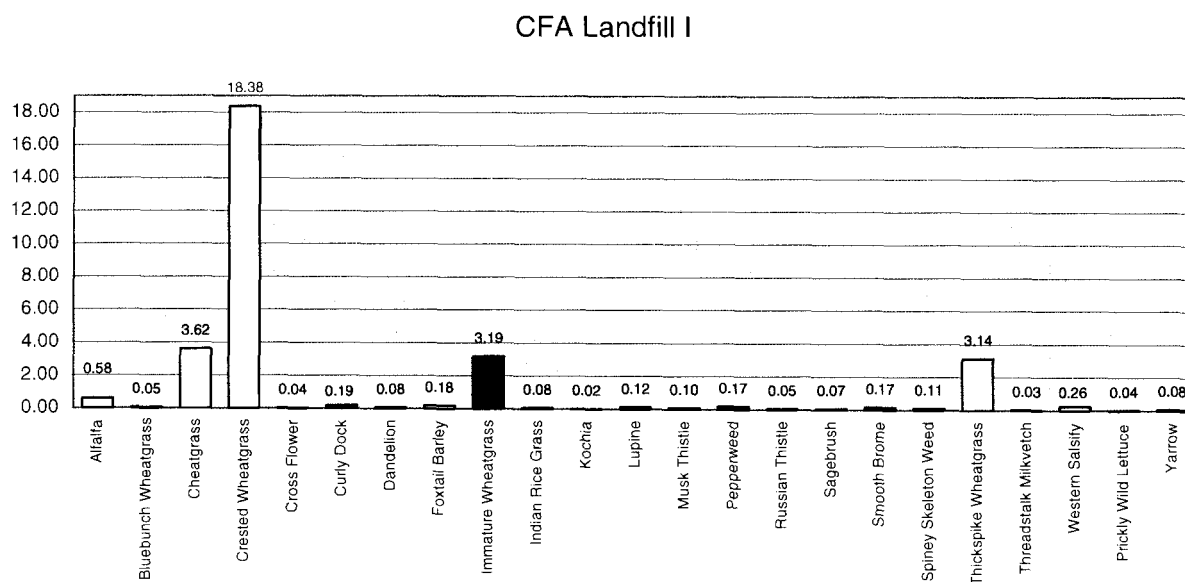


Figure 7-6. Percent cover of all plant species surveyed on Landfill I using the line-intercept method.

Immature wheatgrass, crested wheatgrass, and thickspike wheatgrass were evenly distributed throughout the landfill. Alfalfa was concentrated near the fence line along the south, west, and east sides. Cheatgrass was mainly found on the northeast side of the landfill. The east end of the landfill had the largest variety of plant species and showed beginning signs of successional activities. Along with the cover analysis, the percent frequency was calculated for each plant species identified on CFA Landfill I using the Daubenmire method (see Figure 7-7). The plant species occurring with the highest percent frequency were crested wheatgrass, immature wheatgrass, and alfalfa.

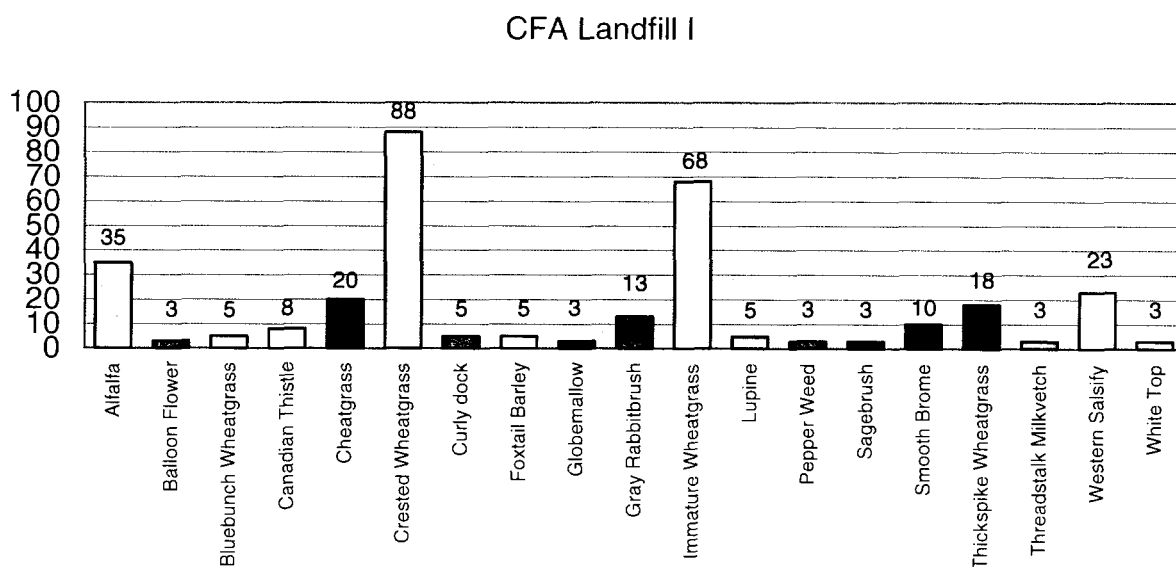


Figure 7-7. Percent frequency of all plant species surveyed in CFA Landfill I using the Daubenmire method.

7.4.2 Results of the Vegetation Surveys on CFA Landfill II

On CFA Landfill II, crested wheatgrass had the highest percent cover. Using the Daubenmire method, the percent cover for crested wheatgrass was 13% and by the line-intercept method, the percent cover was 17% (see Figures 7-8 and 7-9). Immature wheatgrass and grey rabbitbrush were the next plant species with the highest percent of cover for the landfill, at 8 and 5%, respectively, by the Daubenmire method. Using the line-intercept method, immature wheatgrass was the next plant species with the highest percent cover at 7%.

Immature wheatgrass, crested wheatgrass, bluebunch wheatgrass, and thickspike wheatgrass were evenly distributed throughout the landfill. Cheatgrass was concentrated along the north end and Fremont's goosefoot was mainly found in the center. Along with the cover analysis, the percent frequency was calculated for each plant species identified on CFA Landfill II, using the Daubenmire data. The plant species occurring with the highest percent frequency were immature wheatgrass, crested wheatgrass, and bluebunch wheatgrass (see Figure 7-10).

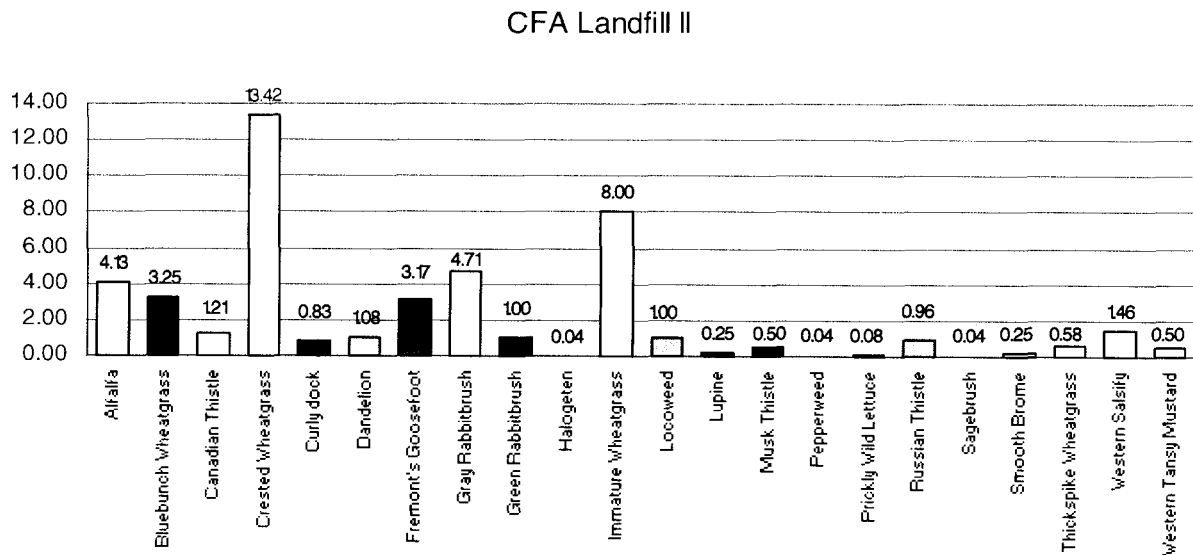


Figure 7-8. Percent cover of all plant species surveyed in CFA Landfill II using the Daubenmire method.

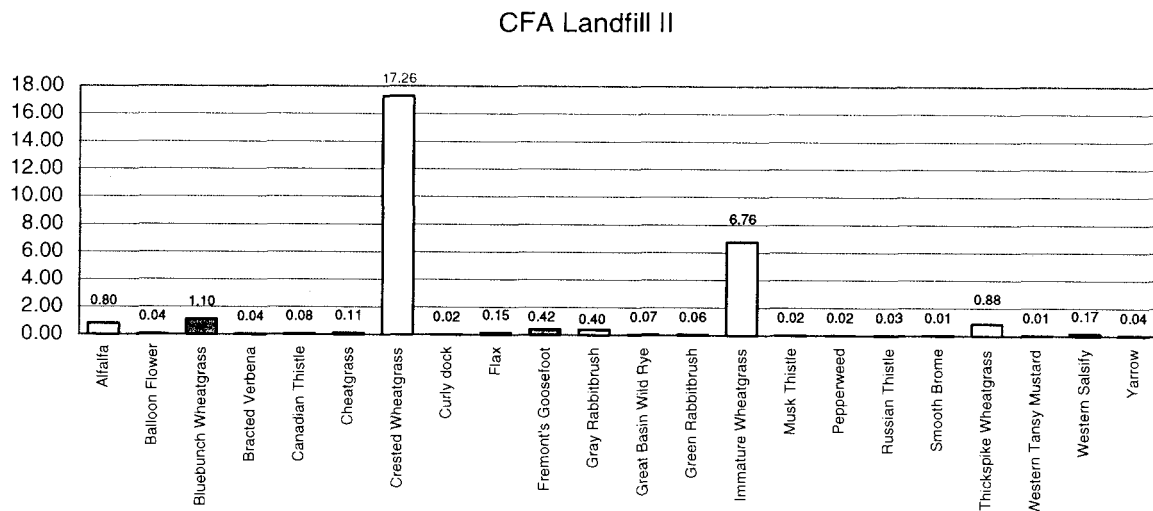


Figure 7-9. Percent cover of all plant species surveyed in Landfill II using the line-intercept method.

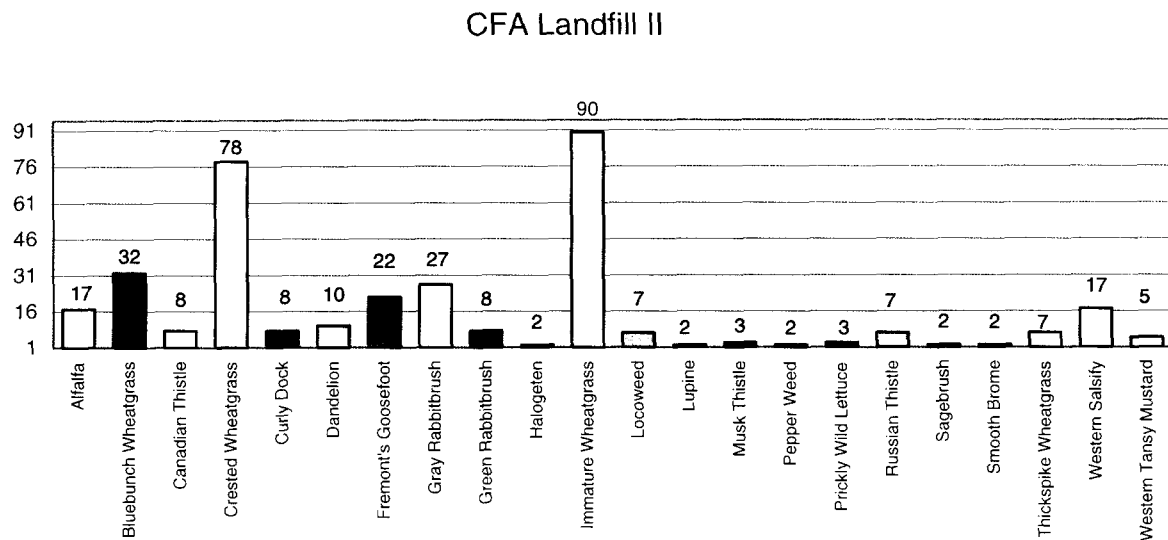


Figure 7-10. Percent frequency of all plant species surveyed in CFA Landfill II using the Daubenmire method.

7.4.3 Results of the Vegetation Surveys on CFA Landfill III

On CFA Landfill III, crested wheatgrass had the highest percent cover. Using the Daubenmire method, the percent cover for crested wheatgrass was 17% and by the line-intercept method, the percent cover was 17% (see Figures 7-11 and 7-12). Alfalfa and immature wheatgrass were the next plant species with the highest percent of cover for the landfill, at 7 and 6%, respectively, by the Daubenmire method. Using the line-intercept method, immature wheatgrass and alfalfa were the next plant species with the highest percent cover at 8 and 5%, respectively.

Immature wheatgrass, crested wheatgrass, bluebunch wheatgrass, and thickspike wheatgrass were evenly distributed throughout the landfill. Canadian thistle was mainly found on the south side, musk thistle on the north end, alfalfa on the south side, and curly dock on the north end. The south side of the landfill had the largest variety of plant species and the beginning signs of successional activities. Along with the cover analysis, the percent frequency was calculated for each plant species identified on CFA Landfill III, using the Daubenmire data. The plant species occurring with the highest percent frequency were crested wheatgrass, immature wheatgrass, and alfalfa (see Figure 7-13).

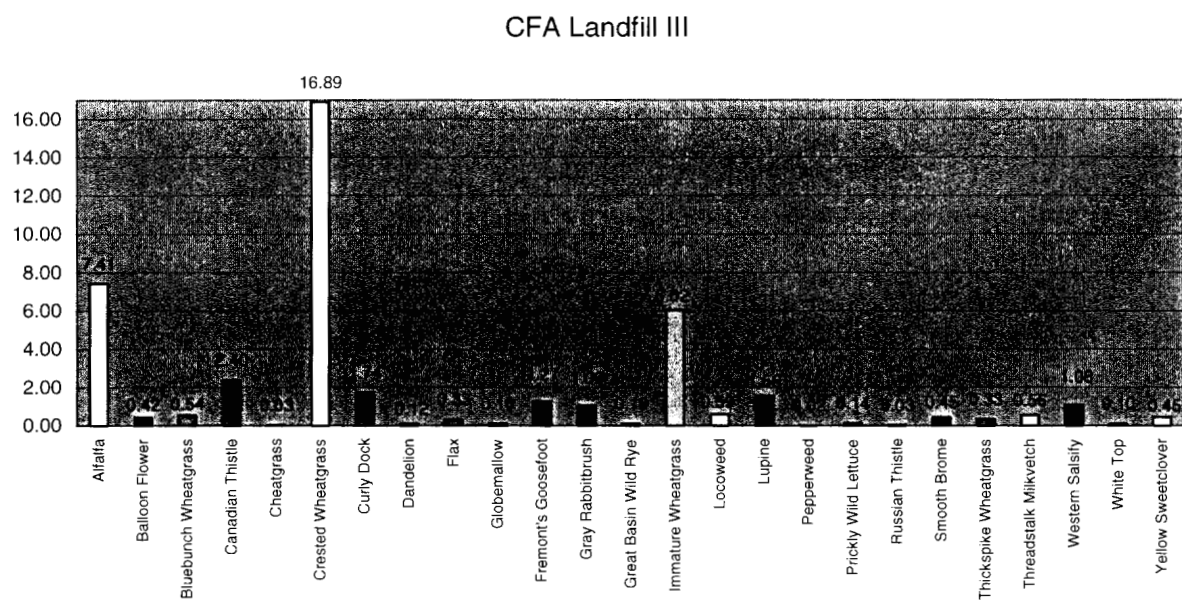


Figure 7-11. Percent cover of all plant species surveyed in CFA Landfill III using the Daubenmire method.

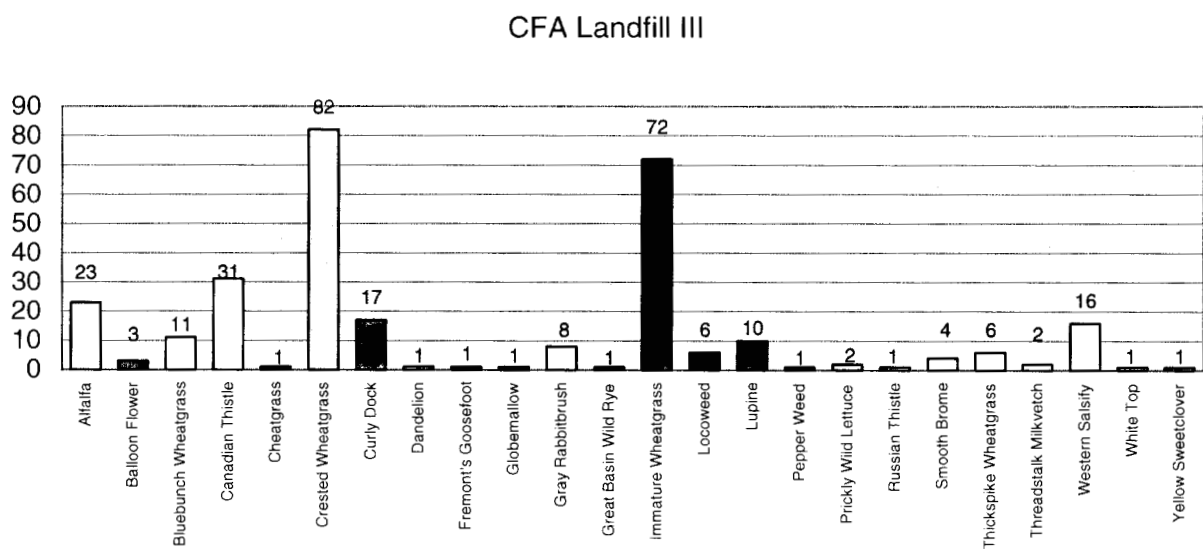


Figure 7-12. Percent cover of all species surveyed in CFA Landfill III using the line-intercept method.

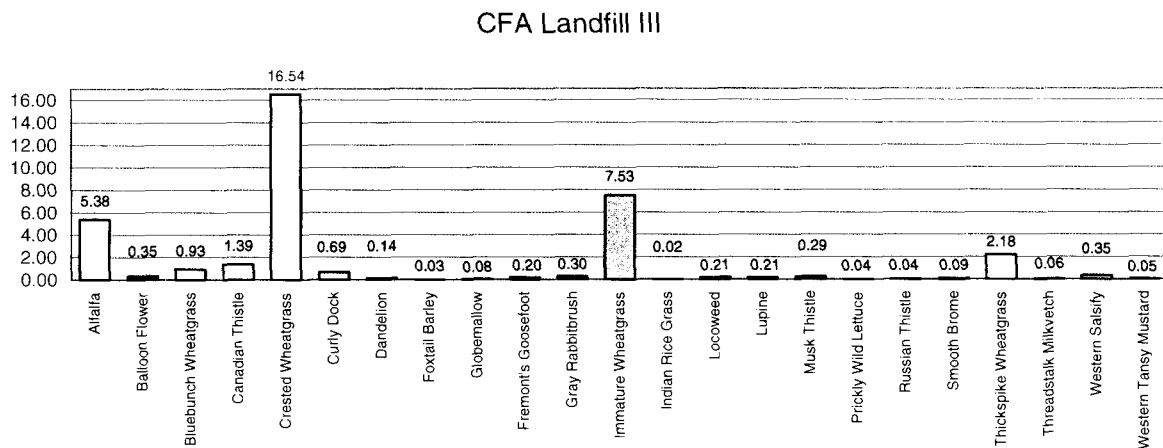


Figure 7-13. Percent frequency of all plant species surveyed on CFA Landfill III using the Daubenmire method.

7.4.4 Results of the Vegetation Surveys on the Control Area

In the control area, sagebrush had the highest percent cover. Using the Daubenmire method, the percent cover for sagebrush was 26% and by the line-intercept method, the percent cover was 9% (see Figures 7-14 and 7-15). Prickly phlox and Indian rice grass were the next plant species with the highest percent of cover for the control area, at 8 and 6%, respectively, by the Daubenmire method. Using the line-intercept method, Indian rice grass, prickly phlox, Russian thistle, and green rabbitbrush were the next plant species with the highest percent cover at 2, 2, 2, and 2%, respectively.

Immature wheatgrass, crested wheatgrass, sagebrush, Indian rice grass, green rabbitbrush, and prickly phlox were evenly distributed throughout the landfill. Needle and thread grass and Russian thistle were concentrated on the north side of the control area. Along with the cover analysis, the percent frequency was calculated for each plant species identified in the control area, using the Daubenmire data. The plant species occurring with the highest percent frequency were sagebrush, Indian rice grass, and prickly phlox (see Figure 7-16).

7.5 The Percent Cover for the CFA Landfill I, II, III and the Control Area using Vegetation Groups

Plant species identified in the CFA landfill vegetation surveys were categorized into three major groups: grasses, weeds, and shrubs. This was done so that the percent cover of each group could be compared with similar vegetation surveys conducted in 2000 by an earlier SAT. Results from this past vegetation study can be found in the *Science Action Team 2000 Report for Waste Area Groups 2 and 4* (Cranney and Lints 2001). The 2000 vegetation study used only two plant groupings: grasses and weeds.

The percent cover for the ground, grasses, and weeds from the 2000 vegetation surveys were 64, 31, and 5%, respectively. The percentage of vegetation versus ground cover from the most recent surveys, at CFA Landfill I is shown in Figure 7-17. The percent cover for the ground, grasses, and weeds from the 2002 vegetation surveys were 69, 29, and 1%, respectively. As compared with the vegetation survey completed in 2000, the percent ground (69%) and grass cover (29%) for Landfill I in 2002 remained about the same. The percent cover for weeds decreased to 1% from 5%. This occurrence was most likely from maintenance activities conducted to rid the landfills of noxious weeds.

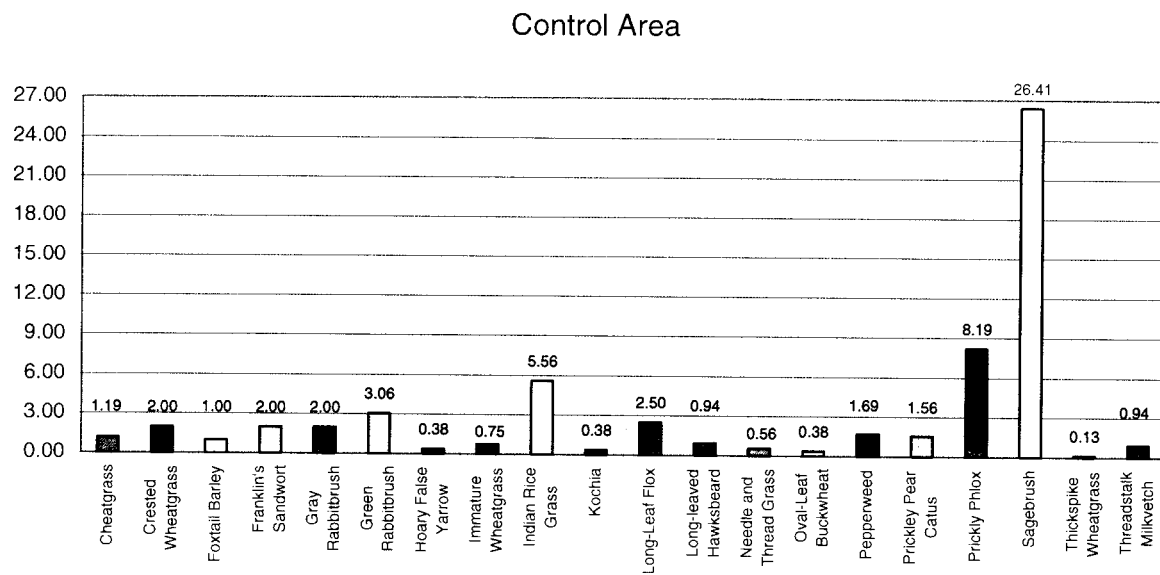


Figure 7-14. Percent cover of all plant species surveyed in the control area using the Daubenmire method.

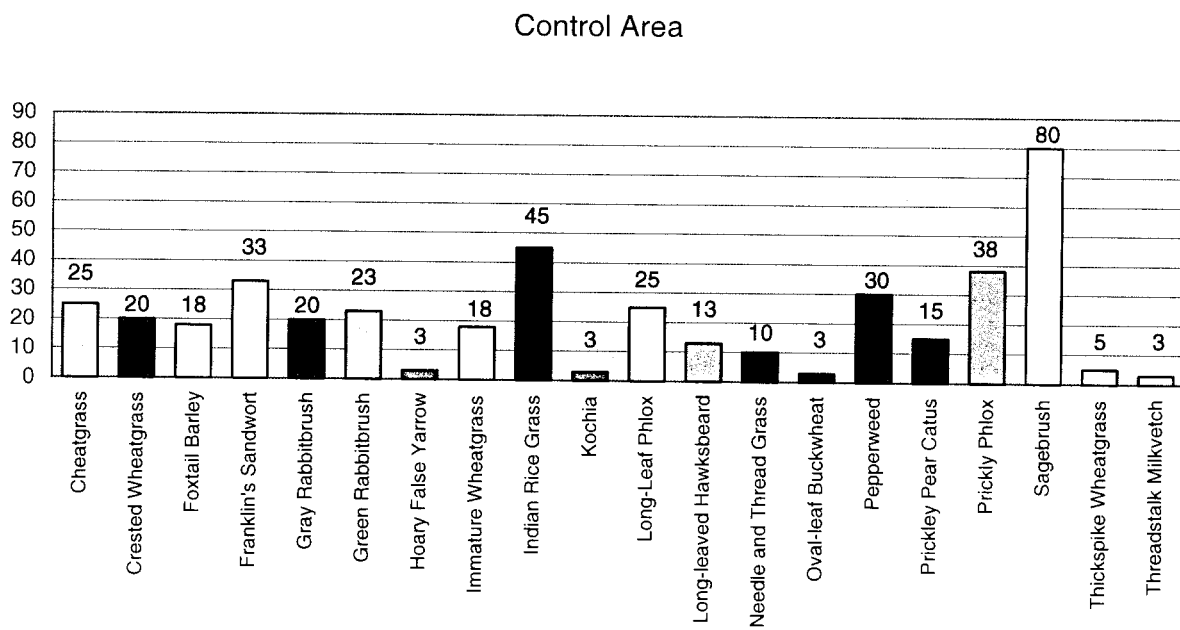


Figure 7-15. Percent cover of all plant species surveyed in the control area using the line-intercept method.

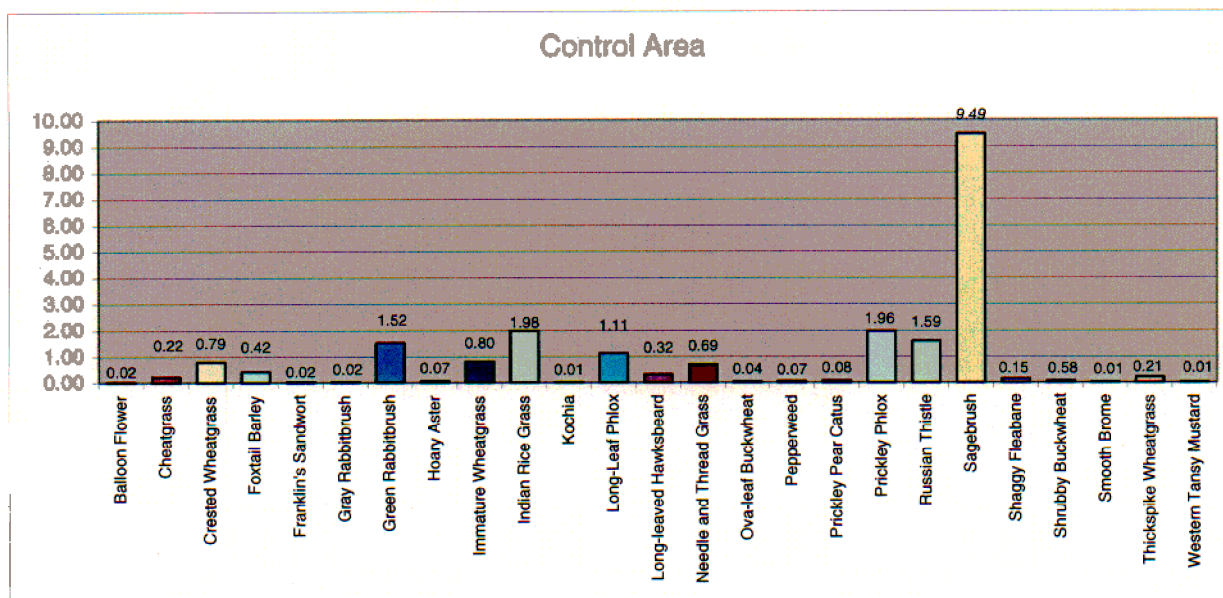


Figure 7-16. Percent frequency of all plant species surveyed in the control area using the Daubenmire method.

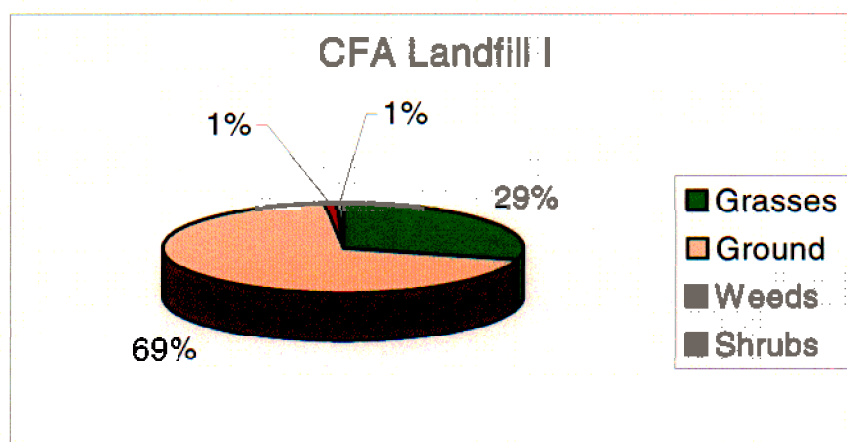


Figure 7-17. The percent cover according to the assigned plant groups at CFA Landfill I.

The percent cover for CFA Landfill II using the plant groups is shown in Figure 7-18. The percent cover of ground, grasses, and weeds from the 2000 vegetation surveys were 76, 20, and 4%, respectively. The percent cover of ground, grasses, and weeds from the 2002 vegetation surveys were 74, 24, and 1%, respectively. The current percentage of ground and grass cover on Landfill II is similar to those reported in the 2000 vegetation study. The percentage of weeds growing on Landfill II has decreased from 4 to 1% since 2000, most likely from maintenance activities conducted to rid the landfills of noxious weeds.

The percent cover for CFA Landfill III using the plant groups is shown in Figure 7-19. The percent cover of ground, grasses, and weeds from the 2000 vegetation surveys were 70, 20, and 10%, respectively. The percent cover of ground, grasses, and weeds from the 2002 vegetation surveys were 79, 16, and 2%, respectively. The current percentage of ground and grass cover on Landfill III is similar to

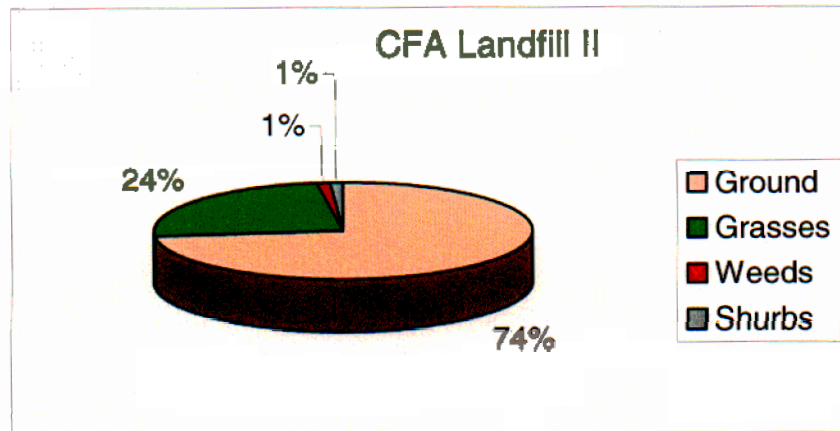


Figure 7-18. The percent cover according to the assigned plant groups at CFA Landfill II.

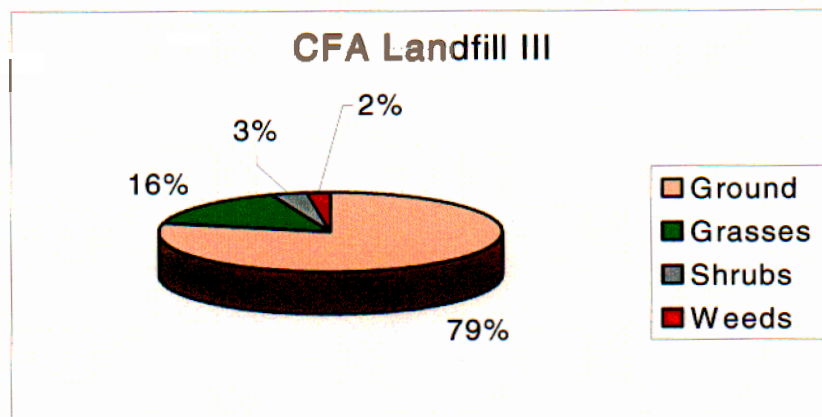


Figure 7-19. The percent cover according to the assigned plant groups at CFA Landfill III.

those reported in the 2000 vegetation study. The percentage of weeds growing on Landfill III has decreased from 10 to 2% since 2000, most likely from maintenance activities conducted to rid the landfills of noxious weeds.

The percent cover for the control area east of CFA Landfill III, using the plant groups, is shown in Figure 7-20. The 2000 study did not include a control area. This area was surveyed to identify those plant species, which could through successional activities have an effect on the CFA landfills in the future (next 50 years). This area had the largest percentage of shrubs and a much smaller percentage of grasses as compared with the CFA landfills. Shrubs are the most abundant plant species and are the most likely to migrate to the CFA landfills. However, many of these plant species take time to get established, so major migratory effects will be more long term (10 to 15 years). The cover percentage for weeds is also higher in the control area than on the landfills. Weeds invade new areas quickly and are therefore, likely to migrate from the control area into the landfills in the near term (next 2 to 4 years).

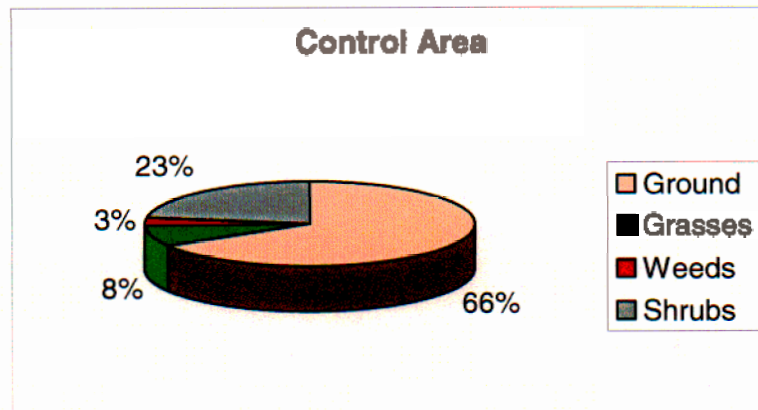


Figure 7-20. The percent cover according to the assigned plant groups in the control area east of CFA Landfill III.

7.6 Changes In Plant Species Since the Revegetation Efforts

Following remediation, the CFA landfills were re-seeded with grasses to prevent erosion, hinder water infiltration, and help preserve the integrity of the compacted soil barriers. Plant species were chosen that would grow quickly and harmonize with the surrounding areas. The following sections discuss the plant species used in the re-vegetation efforts, the species that actually took root in the CFA landfills, the differences in the plant species chosen to revegetate the landfills, and the plant species actually growing on the CFA landfills.

7.6.1 Plants Used to Revegetate the CFA Landfills

Following remedial efforts in 1994, CFA Landfill III was seeded with streambank wheatgrass, needle and thread grass, Indian rice grass, flax, fern-leaved desert parsley, Wyoming big sagebrush; and, in some sections, winterfat (or white sage). All these plant species were chosen for revegetation because they were native to the area. The final remedial action took place in 1996 with the CFA landfills being capped with a compacted soil barrier. Then all three CFA landfills were revegetated with crested wheatgrass, Siberian wheatgrass, and thickspike wheatgrass in the fall of 1996. These plant species did not entirely displace those plant species planted in 1994.

Of the plant species used to re-vegetate CFA Landfill I, II, and III in 1996 only two, crested wheatgrass and thickspike wheatgrass, were observed during the vegetation surveys. Siberian wheatgrass, which is very similar to crested wheatgrass and most likely present in these landfills, may have been misidentified as crested wheatgrass. Some of the native plant species planted in 1994 on CFA Landfill III were observed during the vegetation surveys; these included flax and Indian rice grass. Streambank wheatgrass (which is similar to thickspike wheatgrass) and needle and thread grass may be present on Landfill III, but these plant species could have been missed during the vegetation surveys or misidentified.

7.6.2 Plant Species Currently Growing on the CFA Landfills

Several varieties of plant species were observed and identified during the 2002 vegetation surveys conducted on CFA Landfill I, II, and III. On Landfill I, 28 different plant species were observed in the vegetation studies; on Landfill II, 29 plant species were identified; and on Landfill III, 29 plant species were identified (these numbers include the white clover). The total number of plant species has increased from 15 to 37 since the 2000 vegetation surveys. Plant species identified during the vegetation surveys,

but not used to re-vegetate CFA Landfill I, II, III (except for flax, Indian rice grass, and sagebrush on Landfill III) are included in the following list. The landfill where each plant species was observed is listed in parenthesis next to each of the plant species listed. The number 1 was used to represent Landfill I, the number 2 represents Landfill II, and the number 3 represents Landfill III.

Alfalfa (1 2 3)	Kochia (1)
Balloon flower (1 2 3)	Locoweed (2 3)
Bluebunch wheatgrass (1 2 3)	Lupine (1 2 3)
Bracted verbena (2)	Musk thistle (1 2 3)
Canadian thistle (1 2 3)	Pepperweed (1 2 3)
Cheatgrass (1 2 3)	Prickly wild lettuce (1 2 3)
Cross flower (1)	Russian thistle (1 2 3)
Curly dock (1 2 3)	Sagebrush (1 2)
Dandelion (1 2 3)	Smooth brome (1 2 3)
Flax (3)	Spiny skeleton weed (1)
Fremont's goosefoot (2 3)	Threadstalk milkvetch (1 3)
Foxtail barley (1 3)	Western salsify (1 2 3)
Globemallow (3)	Western tansy mustard (2 3)
Gray rabbitbrush (1 2 3)	White clover (1 2 3)
Great Basin wild rye (2 3)	White top (1 3)
Green rabbitbrush (2 3)	Yarrow (1 2)
Halogeton (2)	Yellow sweetclover (3)
Indian rice grass (1 3)	

A straw mulch was used during the 1996 revegetation efforts and may be the source of the alfalfa and white clover since these plant species are not found in the surrounding areas. Many of these plant species listed above are weeds, grasses, or shrubs that have migrated onto the landfills over the past 6 years.

Crested wheatgrass appears to be the most successful plant species to have rooted in the CFA landfills. Although not native to the area, crested wheatgrass has become a primary plant species in successional trends at the INEEL. The most frequently occurring plant species that have migrated onto CFA Landfill I are smooth brome, gray rabbitbrush, lupine, cheatgrass, western salsify, and Canadian thistle. For CFA Landfill II, frequently occurring migratory plant species include: bluebunch wheatgrass, gray rabbitbrush, Fremont's goosefoot, western salsify, green rabbitbrush, curly dock, and Canadian thistle. On CFA Landfill III, the most frequently occurring migratory plant species are: Canadian thistle, curly dock, western salsify, bluebunch wheatgrass, gray rabbitbrush, and locoweed.

Gray rabbitbrush, western salsify, curly dock, and Canadian thistle are the most common migratory plant species on the CFA landfills. Western salsify, curly dock, and Canadian thistle are weeds and gray rabbitbrush is a native shrub.

7.6.3 Plant Species Observed in the Control Area

Vegetation surveys were also conducted in the control area located east of CFA Landfill III and north of CFA Landfill I. These surveys were intended to identify the variety of plant species located adjacent to the CFA landfills and become aware of those plant species occurring with the highest percent frequency. Future successional activities will involve the movement of plant species from the control area into the CFA landfills. Weeds are typically the first groups of plant species to invade disturbed areas, followed by grasses, forbs, and shrubs.

Twenty-six plant species were identified in the control area. The percent frequency was calculated for each plant species observed in the control area using either the Daubenmire method or the line-intercept method. These percentages are listed in Table 7-9 (this table includes percent frequency for immature wheatgrass). Using the Daubenmire method, big sagebrush was the most frequently occurring plant species in the control area with Indian rice grass, prickly phlox, Franklin's sandwort, and pepperweed with the next highest percentages. Using the line-intercept method, prickly phlox was the most frequently occurring plant species in the control area with sagebrush, green rabbitbrush, Indian rice grass, and immature wheatgrass with the next highest percentages.

Table 7-9. The percent frequency of plant species observed in the control area using the Daubenmire method and the line-intercept method.

Plant Species	Percent Frequency using the Daubenmire Method (%)	Percent Frequency using the Line-Intercept Method (%)
Balloon Flower	—	0.06
Cheatgrass	0.25	0.33
Crested Wheatgrass	0.2	0.50
Foxtail Barley	0.18	0.39
Franklin's Sandwort	0.33	0.06
Gray Rabbitbrush	0.2	0.11
Green Rabbitbrush	0.23	0.89
Hoary Aster	—	0.22
Hoary False Yarrow	0.03	—
Immature Wheatgrass	0.18	0.78
Indian Rice Grass	0.45	0.78
Kochia	0.03	0.11
Long-Leaf Phlox	0.25	0.44
Long-leaved Hawksbeard	0.13	0.17
Needle and Thread Grass	0.1	0.22
Oval-leaf Buckwheat	0.03	0.06
Pepperweed	0.3	0.17
Prickly Pear Cactus	0.15	0.17
Prickly Phlox	0.38	1.00
Russian Thistle	—	0.39
Sagebrush	0.8	0.94
Shaggy Fleabane	—	0.39
Shrubby Buckwheat	—	0.11
Smooth Brome	—	0.06
Thickspike Wheatgrass	0.05	0.33
Threadstalk Milkvetch	0.03	—
Western Tansy Mustard	—	0.06

Note: Shading indicates that this plant species is likely to migrate onto the CFA landfills because of its frequent occurrence in the control area. Plant species used to re-vegetate the CFA landfills in 1996 were not shaded.

The plant species frequently occurring in the control area were shaded in Table 7-9. These species have a high likelihood for migrating onto the CFA Landfills in the future, and several of these species have already been identified on a couple of the CFA landfills. Out of the plant species observed using the Daubenmire method, cheatgrass, foxtail barley, gray rabbitbrush, green rabbitbrush, Indian rice grass, kochia, pepperweed, sagebrush, and threadstalk milkvetch have already been observed on the CFA landfills, and these plant species were not used in the re-vegetation effort. Out of the plant species observed using the line intercept method, that were not observed using the Daubenmire method, balloon flower, Russian thistle, smooth brome, and western tansy mustard have been identified on the CFA landfills. These plant species were also not used in the re-vegetation efforts.

7.7 Rooting Depths of Common Plant Species Identified on the CFA Landfills

Rooting depths of eleven plants species observed on the CFA landfills were located in a literature search. These plant species included alfalfa, sagebrush, bluebunch wheatgrass, Canadian thistle, crested wheatgrass, flax, globemallow, grey rabbitbrush, green rabbitbrush, western salsify, and yellow sweet clover. The maximum rooting depths are listed in Table 7-10. These rooting depth results were found in a literature search for studies conducted in sagebrush-steppe habitat or on the INEEL. The compacted soil barriers range in thickness from 61 to 76 cm (24 to 30 in.) on each of the landfills. The compacted soil layer may shorten the depth the plant species may penetrate; however, this layer is only 15 cm (6 in.) thick. The maximum rooting depths are the worse case scenario although the average rooting depth for these plant species may be much shorter.

Table 7-10. The maximum rooting depths of common plant species found in the CFA landfills and the control area.

Plant Species	Maximum Rooting Depth (cm)	Reference
Alfalfa (<i>Medicago sativa</i>)	198	Weaver (1926)
Sagebrush (<i>Artemisia tridentata</i>)	225	Reynolds and Fraley (1989)
Bluebunch Wheatgrass (<i>Pseudoroegneria spicata</i>)	200	McKenzie et al. (1982)
Canadian Thistle (<i>Cirsium Canadensis</i>)	60	Mitchell and Davis (1996)
Cheatgrass (<i>Bromus tectorum</i>)	76	McKenzie et al. (1982)
Crested Wheatgrass (<i>Agropyron cristatum</i>)	100	Abbott, Fraley, and Reynolds (1991)
Flax (<i>Adenolinum lewisii</i>)	122	Lafond et al. (1996)
Globemallow (<i>Sphaeralcea munroana</i>)	183	USDA Forest Service (2001)
Gray Rabbitbrush (<i>Chrysothamnus nauseosus</i>)	240	Klepper et al. (1978)
Green Rabbitbrush (<i>Chrysothamnus viscidiflorus</i>)	100	Abbott, Fraley, and Reynolds (1991)
Indian Rice Grass (<i>Oryzopsis hymenoides</i>)	150	Reynolds and Fraley (1989)
Western Salsify (<i>Tragopogon dubius</i>)	137	McKenzie et al. (1982)
Yellow Sweetclover (<i>Melilotus officinalis</i>)	137	McKenzie et al. (1982)

Gray rabbitbrush and sagebrush have the deepest rooting depths at 240 and 225 cm (94 and 89 in.) respectively. Gray rabbitbrush was observed on all three CFA landfills during the vegetation surveys and big sagebrush was observed on CFA Landfills I and II. These native brushes were not used in the 1996 revegetation process, but are commonly found in the surrounding areas around CFA Landfills I, II, and III and the control area. The plant species with the next deepest rooting depths were alfalfa at 198 cm (78 in.) and globemallow at 183 cm (72 in.). Alfalfa was identified on all three landfills and globemallow was only observed on CFA Landfill III. A straw mulch used during the 1996 revegetation efforts may have been the source of the alfalfa since this plant species is not found in the surrounding areas. Globemallow is a native forb and is commonly found in the areas surrounding the CFA landfills. As well as having deep rooting depths, gray rabbitbrush, sagebrush, alfalfa, and globemallow provide the most overhead cover for small mammals to hide under at the CFA landfills.

The primary purpose of the vegetation cover planted on the CFA landfills was to prevent erosion and absorb moisture from the soil. However, deep rooting plant species may penetrate down into the waste, incorporate contaminants into their biomass, and transport it up to the surface. Decaying roots may also leave small channels for moisture to travel more readily through the compacted soil barrier into the buried waste. Although plant roots are good for keeping the soil moisture down and for limiting the depth precipitation may travel, they may dry out the soil causing cracking and shrinking of the compacted soil barrier allowing precipitation to seep through the soil barrier. These issues are beyond the scope of this report and will be addressed further in, EDF-2482.

8. RESULTS SUMMARY AND CONCLUSIONS

The SAT determined small mammal populations at CFA Landfills I, II, III, and the control area using capture-recapture methods and the Peterson-Lincoln index. They also conducted vegetation surveys using the Daubenmire and line-intercept methods. The results of these studies were used to determine the percent cover and the percent frequency of all observed plant species on CFA Landfills I, II, III and the control area. The following sections discuss the results and conclusions of the small mammal population calculations, the burrowing depth findings from the literature search, the results of the vegetation surveys, the plant rooting depth findings from the literature search, and the current successional changes of plant species on CFA Landfills I, II, and III.

8.1 Summary of Small Mammal Densities and Burrowing Depth Results

Results of the small mammal density calculations are summarized in Table 8-1. The most abundant rodents are deer mice on CFA Landfill II, Great Basin pocket mice on CFA Landfill I, least chipmunk on CFA Landfill I and the control area, and the Ord's kangaroo rat on CFA Landfill II.

Following remediation, the compacted soil barriers on the CFA Landfills ranged from 61 to 76 cm (24 to 30 in.) in depth. The Townsend's ground squirrel had the deepest burrowing depth in the literature search at 140 cm (55 in.), but was only captured on CFA Landfill III. The Richardson's ground squirrel was also captured on CFA Landfill III; however, the burrowing depth of this small mammal species was not found in the literature search. These two squirrels have the highest potential for burrowing down into the buried waste, but only if burrows were created in the compacted soil barrier on CFA Landfill III. Of the small mammal species with estimated population sizes, the Great Basin pocket mouse and the Ord's kangaroo rat have the deepest burrowing depth at 61 cm (24 in.) (see Table 8-1). The compacted soil layer may limit the depth to which small mammals may burrow but this layer is only 15 cm (6 in.) thick. These small mammals could reach the buried waste; however, because their population size is much larger than the ground squirrels, then the greater hazard comes from the number of burrows created in the compacted soil barrier. The total number of small mammal burrows from mice and possibly rats is much higher than those created by squirrels (see Table 7-7). These entrances and tunnels may allow precipitation to travel through the compacted soil barriers more readily.

Further analysis is needed before issues concerning the compacted soil barrier's integrity can be addressed for long-term impacts from biological processes. This additional analysis will be presented in a subsequent report, EDF-2482.

The total number of small mammals per square foot, using the population estimates and the areas of each landfill, was $1.17\text{E-}04$ for Landfill I, $8.57\text{E-}05$ for Landfill II, and $2.75\text{E-}05$ for Landfill III. Landfill I had the greatest number of small mammals relative to its size.

Table 8-1. Summary of populations and burrowing depths of common small mammals captured on CFA Landfills I, II, II, and the control area.

CFA Landfill I		
Species	Population ^a	Burrowing Depth ^b (cm)
Deer Mouse	27	50
Great Basin Pocket Mouse	11	61
Least Chipmunk	4	31
CFA Landfill II		
Species	Population ^a	Burrowing Depth ^b (cm)
Deer Mouse	46	50
Ord's Kangaroo Rat	10	61
CFA Landfill III		
Species	Population ^a	Burrowing Depth ^b (cm)
Deer Mouse	11	50
Great Basin Pocket Mouse	4	61
Control Area		
Species	Population ^a	Burrowing Depth ^b (cm)
Deer Mouse	12	50
Least Chipmunk	4	31
a. If the number of small mammal species recaptured was less then 8 than the population size may be overestimated (Krebs 1989).		
b. The reference for the burrowing depths can be found in Table 7-6.		

8.2 Summary of the Vegetation Density and Cover Analysis and Rooting Depth Results

Results of the vegetation density and cover analysis are listed in Table 8-2. For CFA Landfill I, the plant species with the highest percent cover and frequency was crested wheatgrass. Using the Daubenmire method, immature wheatgrass, alfalfa, and cheatgrass were the next plant species with the highest percent cover, and by the line-intercept method, cheatgrass, immature wheatgrass and thickspike wheatgrass were the next plant species with the highest percent cover.

For CFA Landfill II, the plant species with the highest percent cover was crested wheatgrass. Using the Daubenmire method, immature wheatgrass, gray rabbitbrush, and alfalfa were the next plant species with the highest percent cover, and by the line-intercept method immature, wheatgrass, alfalfa, and bluebunch wheatgrass were the next plant species with the highest percent cover.

Table 8-2. Summary of percent cover, percent frequency, and rooting depths of the most common plant species identified on CFA Landfills I, II, III, and the control area.

CFA Landfill I				
Plant Species	Percent Cover (%) Daubenmire Method	Percent Cover (%) Line-intercept Method	Percent Frequency (%) Daubenmire Method	Maximum Rooting Depth (cm)
Alfalfa	4	1	35	198
Cheatgrass	2	4	20	76
Crested Wheatgrass	24	18	88	100
Immature Wheatgrass	7	3	68	N/D
Thickspike Wheatgrass	1	3	18	N/D
CFA Landfill II				
Plant Species	Percent Cover (%) Daubenmire Method	Percent Cover (%) Line-intercept Method	Percent Frequency (%) Daubenmire Method	Maximum Rooting Depth (cm)
Alfalfa	4	1	17	198
Bluebunch Wheatgrass	3	1	32	200
Crested Wheatgrass	13	17	78	100
Fremont's Goosefoot	3	0.42	17	N/D
Gray Rabbitbrush	5	0.40	27	240
Immature Wheatgrass	8	7	90	N/D
CFA Landfill III				
Plant Species	Percent Cover (%) Daubenmire Method	Percent Cover (%) Line-intercept Method	Percent Frequency (%) Daubenmire Method	Maximum Rooting Depth (cm)
Alfalfa	7	5	23	198
Canadian Thistle	2	1	34	60
Crested Wheatgrass	17	17	82	100
Immature Wheatgrass	6	8	72	N/D
Thickspike Wheatgrass	0.33	2	6	N/D
Control Area				
Plant Species	Percent Cover (%) Daubenmire Method	Percent Cover (%) Line-intercept Method	Percent Frequency (%) Daubenmire Method	Maximum Rooting Depth (cm)
Green Rabbitbrush	3	2	23	76
Indian Rice Grass	6	2	45	150
Long-leaf Phlox	3	1	25	N/D
Prickly Phlox	8	2	38	N/D
Russian Thistle	—	2	—	N/D
Sagebrush	26	9	80	225
N/D = Not Determined. Rooting depths for these plant species were not found in the literature search.				
a. The reference for the maximum rooting depth of each plant species is listed in Table 7-10.				

For CFA Landfill III, the plant species with the highest percent cover and frequency was crested wheatgrass. Using the Daubenmire method, alfalfa, immature wheatgrass, and Canadian thistle were the next plant species with the highest percent cover, and by the line-intercept method, immature wheatgrass, alfalfa, and thickspike wheatgrass were the next plant species with the highest percent cover.

For the control area, the plant species with the highest percent cover and frequency was sagebrush. Using the Daubenmire method, prickly phlox and Indian rice grass were the next plant species with the highest percent cover, and by the line-intercept method, green rabbitbrush, Indian rice grass, prickly phlox, and Russian thistle were the next plant species with the highest percent cover.

The maximum rooting depths for the most frequently observed plant species on CFA Landfill I, II, III, and the control area are listed in Table 8-2. Following the remedial action, the compacted soil barriers range in thickness from 61 to 76 cm (24 to 30 in.) on each of the landfills. The compacted soil layer may shorten the depth the plant species may penetrate; however, this layer is only 15 cm (6 in.) thick. The maximum rooting depths are presented as the worse case scenario although the average rooting depth for these plant species may be much shorter.

The most frequently occurring plant species, on CFA Landfill I are crested wheatgrass, alfalfa, and cheatgrass (immature wheatgrass was not included because the plant species is undetermined) with maximum rooting depths at 100, 198, and 76 cm (39, 78, and 30 in.), respectively. The most frequently occurring plant species on CFA Landfill II are crested wheatgrass, gray rabbitbrush, and alfalfa (immature wheatgrass was not included because the plant species is undetermined) with maximum rooting depths at 100, 240, and 198 cm (39, 95, and 78 in.), respectively. The maximum rooting depth for the Fremont's goosefoot was not found in the literature search. The most frequently occurring plant species on CFA Landfill III are crested wheatgrass, Canadian thistle, and alfalfa (immature wheatgrass was not included because the plant species is undetermined) with maximum rooting depths at 100, 60, and 198 cm (39, 24, and 78 in.), respectively. The most frequently occurring plant species in the control area are sagebrush, Indian rice grass, and prickly phlox. The maximum rooting depths of sagebrush and Indian rice grass are 225 and 150 cm (89 and 59 in.), respectively. The maximum rooting depth for the prickly phlox was not found in the literature search.

Further analysis is needed before issues concerning the compacted soil barrier's integrity can be addressed for long-term impacts from biological processes. This additional analysis will be presented in a subsequent report, EDF-2482.

8.3 Current Successional Changes of Plant Species on CFA Landfills I, II, and III

In 1994, before the final remedial action, CFA Landfill III was revegetated in some sections with streambank wheatgrass, needle and thread grass, Indian rice grass, flax, fern-leafed desert parsley, Wyoming big sagebrush, and winterfat (or white sage). Following the installation of the compacted soil barriers in 1996, all three landfills were revegetated with crested wheatgrass, Siberian wheatgrass, and thickspike wheatgrass.

Successional activities on the CFA landfills were tracked in 2000 by a SAT. This team found 15 plant species on the three landfills. Plant species observed that were not used in the revegetation process were:

- Western Salsify
- Canadian Thistle

- Curly Dock
- Alfalfa
- Musk Thistle
- Yellow Sweetclover
- Green Rabbitbrush
- Prickly Wild Lettuce
- Lupine
- Locoweed
- Bluebunch Wheatgrass
- Cheatgrass
- Foxtail Barley.

The number of observed plant species increased in the 2002 vegetation surveys conducted on CFA Landfill I, II, and III. The SAT observed 28 different plant species on Landfill I, 29 plant species on Landfill II, and 29 plant species on Landfill III. The total number of plant species increased since the 2000 vegetation surveys from 15 to 37. These 37 plant species are listed in Section 7-4.

The control area was evaluated for plant species that are likely to migrate or increase their frequency on the landfills. The most abundant species according to percent frequency in the control area, included:

- Cheatgrass
- Foxtail Barley
- Franklin's Sandwort
- Green Rabbitbrush
- Hoary Aster
- Indian Rice Grass
- Long-Leaf Phlox
- Needle and Thread Grass
- Pepperweed
- Prickly Phlox

- Russian Thistle
- Sagebrush
- Shaggy Fleabane.

Further analysis is needed before issues concerning the compacted soil barrier's integrity can be addressed for long-term impacts from biological processes. This additional analysis will be presented in a subsequent report, EDF-2482.

9. SUMMARY

The purpose of this assessment was to provide more information regarding the long-term threats to the CFA landfill's compacted soil barrier's integrity from biological processes, and to provide information to help direct future monitoring activities at the CFA landfills. Field personnel trapped small mammals at four locations on the INEEL: (1) CFA Landfill I, (2) CFA Landfill II, (3) CFA Landfill III, and (4) a control area east of CFA Landfill III. The results from this effort will be used to help determine which small mammal species home ranges overlap the landfills, and to help identify those species potentially impacting the integrity of the caps. Field personnel also conducted a vegetation density and cover analysis at the CFA landfills and the control area. This information was used to determine the vegetation densities of plant species growing on the three compacted soil barriers. In addition to the density evaluations, a literature search was conducted to determine the burrowing depths of the most common small mammal species, and rooting depths of the most common plant species identified on the CFA landfills and the control area.

Results from these studies will help to identify issues and concerns needing further investigation in evaluating the long-term effects from biological processes on the compacted soil barriers at the CFA landfills. The final analysis will be published subsequent to this report in EDF-2482 "Analysis of the Natural Physical and Biological Processes Potentially Affecting the Long-Term Performance of the Compacted Soil Barriers on the CFA Landfills" (in preparation).

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